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ARMSTRONG LABORATORY

THE K-36D EJECTION SEAT FOREIGN COMPARATIVE TESTING (FCT) PROGRAM

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FOR THE DIRECTOR

Thomas J. Moore

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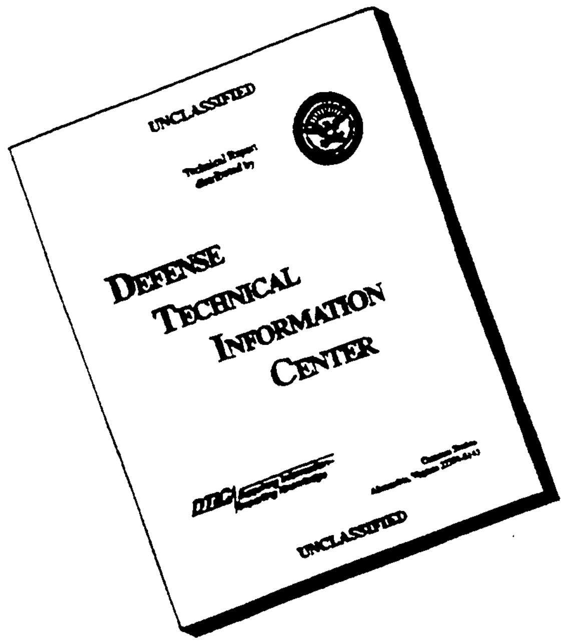

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The K-36D Ejection Seat Foreign Comparative Testing (FCT) Program

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In 1989 at the Paris Air Show, a K-36D ejection seat gained wide public attention when the pilot successfully ejected from a MiG-29 after an extremely low altitude engine failure. The K-36D is standard equipment in Russian high-performance aircraft, being rated for survivable ejections at speeds of 0-755 KEAS. In 1993, a Foreign Comparative Testing (FCT) Program was initiated to evaluate the Soviet designed K-36D ejection seat. The objectives of this program were to increase USAF/USN knowledge of the state of Russian ejection seat technology, confirm or refute Russian claims on the performance of the K-36D ejection seat and associated personnel equipment, determine the relevance of Soviet ejection seat technology and flight crew equipment to development of a technology base for expansion of the performance envelope of USAF/USN escape systems and to develop working relationships between the US and Russian technical teams. The program consisted of eight ejections from modified MiG-25 aircraft at altitudes up to 56,000 ft at Mach 2.5, and three rocket sled tests at speeds up to 755 KEAS. This report discusses the K-36 FCT Program and the results of the ejection testing, comparing the performance of the K-36D to that of current Western ejection seats.

Crew Escape | Ejection Seat | Ejection Seat Stability | 436

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PREFACE

The tests of the Russian K-36D ejection seat described within were conducted by the United States (US) Air Force and the US Navy. These tests were accomplished in the Former Soviet Union (FSU) at the Zvezda design bureau, the Flight Research Institute, and the Scientific Research Institute of Aviation Systems during August and September of 1993. The Zvezda Design Bureau is represented in international cooperative efforts through IBP Aircraft Limited (IBP) of the UK with an agreement known as a joint venture abroad. Any contractual arrangements must be made through IBP. This agreement eliminates the need to deal directly with the government of the Former Soviet Union and facilitates the negotiations. IBP is under contract to Rockwell International to assist in establishing the cost of ejection systems and related ejection seat testing. Rockwell is under contract to the USAF to facilitate the conduct of the program. Mr. Lawrence J. Specker was the contract monitor and technical program manager for this effort.

Systems Research Laboratories (SRL) was also under contract to the Air Force to acquire the instrumentation and computing equipment as specified by the US Air Force. They were also responsible for the maintenance and operation of the manikins while in Russia as well as the shipment of all related test equipment. Mr. John A. Plaga was the SRL task manager for this effort.

Mr. James W. Brinkley was the K-36 FCT program manager.

Figure 1. K-36D Ejection From a MiG-29 Featured on the Cover of *Aviation Week & Space Technology*

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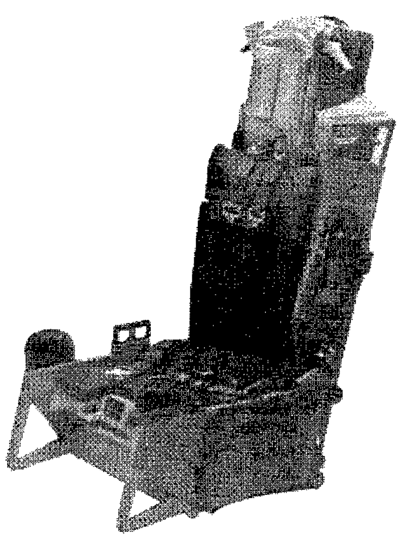
ABBREVIATIONS

SYMBOL	DEFINITION
ACES	Advanced Concept Ejection Seat
ADAM	Advanced Dynamic Anthropomorphic Manikin
ADAS	ADAM Data Acquisition System
AFB	Air Force Base
AGL	Above Ground Level
ASL	Above Sea Level
CREST	CRew EScape Technologies
DR	Dynamic Response
DRI	Dynamic Response Index
FSU	Former Soviet Union
IBP	IBP Aircraft Ltd
KEAS	Knots Equivalent AirSpeed
KKO-5	Russian High-speed/High Altitude Full Pressure Suit Complex
KKO-15	Russian Standard Flight Gear Complex
Kph	Kilometers per hour
NACES	Naval Aircrew Common Ejection Seat
MASE	Multi-Axis Sled Ejection
MDMSC	McDonnell Douglas Missile Systems Corporation
MDRC	Multi-Axial Dynamic Response Criteria
MiG	Mikoyan-Gurevich - Russian Aircraft Manufacturer
POS	Parachute Opening Shock
SKIF	Russian Test Manikin
SRL	Systems Research Laboratory
STD	Standard
SU	Suchoi - Russian Aircraft Manufacturer
US	United States
USAF	United States Air Force
USN	United States Navy
VDC	Voltage Direct Current

INTRODUCTION

Background

The ejection seat currently in USAF service is the Advanced Concept Ejection Seat (ACES II) manufactured by McDonnell Douglas. Based on pre-1970 technology, the ACES II has been in use since 1976, with over 7000 units installed in fixed-wing tactical and strategic aircraft. While the ACES II performance limit is cited as 600 Knots Equivalent AirSpeed (KEAS), few successful ejections have occurred over 500 KEAS and none over 600 KEAS. It is suspected that the actual envelope has a much lower, top-end speed. The envelopes of ejection seats with poor directional stability and little or no windblast protection are limited by the occurrence of ejection related injuries rather than the ability of the seat to withstand the aerodynamic and inertial loads imposed during emergency escape. Ejection seat statistics clearly show an increased potential for major injury and fatality at speeds over 425 KEAS. Navy experience with their Martin-Baker Mk-7 seat is similar. During the Vietnam war, many US aircrew ejected near the upper flight limits of their aircraft and incurred severe or fatal injuries due to high aerodynamic forces. Nevertheless, the US has, in recent years, concentrated in improving aircraft escape in the adverse attitude regime at 100 knots and below. It appears likely that the life saving inadequacy of current US ejection seats will become more evident with the advent of the F-22 and other future tactical aircraft whose operational envelope will involve sustained flight above 600 KEAS.



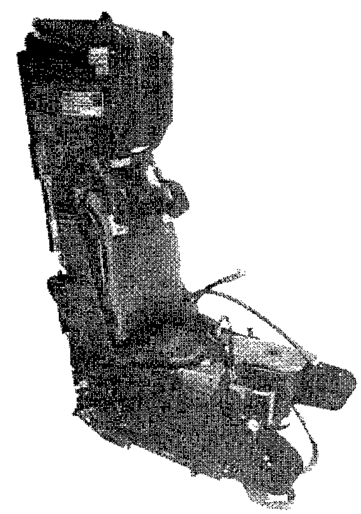


Figure 2. ACES II Ejection Seat (left) and NACES Ejection Seat (right)

The US escape community has continued to develop the technologies required to field a safe, high-speed, adverse attitude ejection seat but has lagged in the demonstration of an advanced ejection seat capable of providing safe escape within the required envelope. In 1984, the Crew Escape Technologies (CREST) Advanced Development Program was initiated at the Armstrong Laboratory to demonstrate advanced ejection seat technologies that would allow safe escape at high-speed and adverse attitudes up to 50,000 feet and Mach 3. The program was characterized by technologies such as controlled rocket thrust vectoring, active flight stabilization, trajectory control, and windblast protection, to provide safe escape at speeds up to 700 KEAS. While much progress was made during this effort, problems with the propulsion design resulted in the termination of the contract with Boeing Aircraft, the primary contractor. The program has been revised recently as part of a joint Air Force and Navy venture. This program is the Fourth Generation Ejection System Technologies Demonstration program, under primary contract to McDonnell Douglas Missiles Systems Company (MDMSC), to demonstrate: (a) a controllable propulsion system, (b) controlled flight of an ejection seat at speeds of 475 knots equivalent airspeed (KEAS) with adverse launch conditions, (c) safe escape which includes windblast protection at speeds up to 700 KEAS.

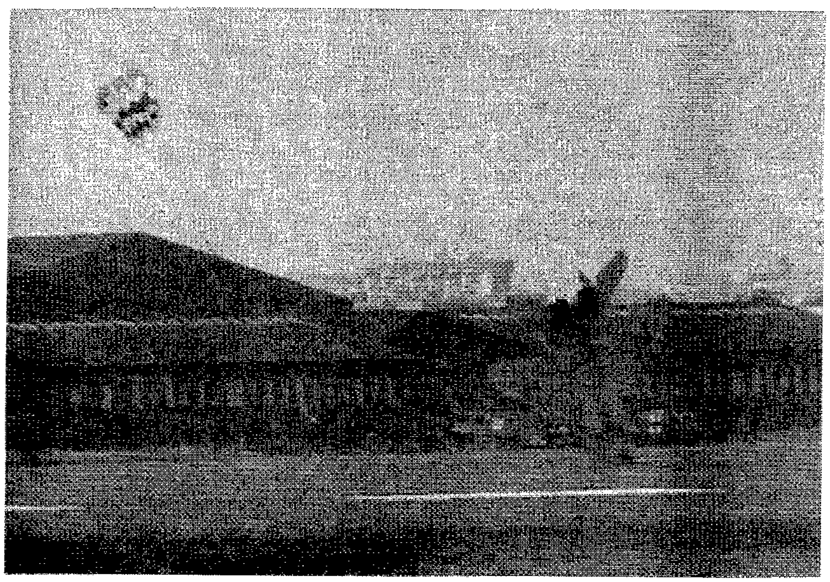


Figure 3. K-36D Ejection at 1989 Paris Airshow

At the 1989 Paris Air Show, a Russian-made K-36D seat gained wide public attention when the pilot successfully ejected from a MiG-29 after engine failure at an altitude of 300 ft with the aircraft in an 80 degree pitch down attitude. The airspeed at ejection was approximately 100 knots. Although the parachute deployment occurred when the pilot was only 10 to 20 ft above ground, he survived with little more than bruises on his back,

abdomen, and a small cut on his right eyelid. The K-36D ejection seat is standard equipment in Soviet high performance combat aircraft, and is rated for survivable ejections at speeds of 0-1400 km/hr (0-755 KEAS) and altitudes of zero to 80,000 ft . This is in contrast to US ejection seats which are designed for ejection speeds of 0-1110 km/hr or 0-600 KEAS. In August 1990, Professor Guy Illich Severin, General Manager of Zvezda, met with Mr. James W. Brinkley of the Armstrong Laboratory and Col A. Michael Higgins from the office of the Secretary of the Air Force, Acquisition and Technology, in the Pentagon, to discuss Soviet and American made escape systems. Professor Severin expressed an interest in providing the K-36 seat for use in USAF aircraft. In September 1991, the advanced planning office of the Air Force Systems Command advised the Armstrong and Wright Laboratories, the USAF activities responsible for escape system R&D, that they may have the opportunity to obtain a K-36 ejection seat and various life support systems to study in their research on aircrew life support systems. In their replies, both laboratories supported the evaluation of the K-36. This FCT program was a direct result of those responses.

Program Objectives

The objectives of the program were to increase USAF/USN knowledge of the state of Russian ejection seat technology, verify or refute Russian claims on the performance of the K-36D ejection seat and associated personnel equipment, determine the relevance of Soviet ejection seat technology and personal equipment to the technology base for expansion of the performance envelope of USAF/USN escape systems, and develop working relationships between the US and FSU ejection systems communities to facilitate the exchange of technical information including test and evaluation methods, criteria, and data.

The purpose of this comparative test program was to conduct baseline tests of the Russian K-36D ejection seat. The tests would provide baseline data for comparison of the performance of the K-36D ejection seat to other ejection seats currently used in US aircraft. The performance features of specific subsystems were also of interest to the US. These included the crew restraint system, restraint tensioning device, aerodynamic stabilizing devices, windblast protection shield, propulsion rocket, crew recovery parachutes, high-Mach thermal protection equipment, pressure suits, sequencing systems and integration issues of the seat with air vehicle and personal equipment.

Evaluation Criteria

Objective evaluation criteria were used as available. Ejection seat acceleration environments were evaluated using Air Force accepted criteria for the estimation of the probability of spinal injury while the seat is on the ejection rails of the aircraft and the multi-axial acceleration environment during the free-flight portion of the ejection process. Total forces acting on the head, hands, and lower leg were compared to the best known limits used in human impact studies and information obtained from cadaver tests. Parachute opening shock loads were also evaluated using accepted maximum acceleration limit loading and also by application of the spinal injury criteria previously used during the catapult phase. Also, where possible, all indices were compared to those generated during US ejection seat tests.

TECHNICAL APPROACH

To the extent possible, the objectives, program requirements, demonstration test conditions and performance criteria of the ongoing advanced development program were addressed. US Government engineers conducted the tests. US and Russian instrumentation was employed, and with US instrumentation, it was employed in accordance with USAF test protocols. Standard escape system test procedures of both countries were followed. The seats and manikins were extensively instrumented to obtain all desired data. Parameters that were measured included seat and crewmember mounted total pressures, seat and crewmember accelerations and angular rates in three axes, head and lumbar forces and moments, lower leg forces, and parachute riser loads.

A "dual track" approach was in operation with the conduct of this program. The first "track" involved testing in the US. Testing was accomplished at facilities located at Wright-Patterson AFB and Holloman AFB to develop the hardware and associated test software required to meet the extensive K-36 program measurement requirements. Both ejection seat performance and tolerability to the accelerations encountered during the emergency escape were evaluated. The Advanced Dynamic Anthropomorphic Manikin (ADAM) was thoroughly tested at the Armstrong Laboratory at Wright-Patterson to measure and observe its ability to react to the stress environment as a crewmember would, and record the forces, moments and accelerations that are acting within, and on, its body. The ADAM also was tested during high-speed rocket sled tests at Holloman AFB to test its capabilities and strength during ejections up to speeds of 600 KEAS. These tests also supported the CREST advanced development program.

The second "track" was the largest part of the program. It included review of available K-36D ejection seat data and tests at the Russian facilities. In this second track, the K-36D was tested at the Russian Big Vertical Catapult Tower, The Aerodynamic Wind Tunnel facility, the High-Speed Rocket Sled test facility and the MiG-25 Flying Laboratory. The range of capabilities at the facilities allowed the US Government engineers to conduct tests that couldn't be accomplished in the continental US. The majority of these tests were performed using the Russian MiG-25 Flying Laboratory, allowing the ejection of the K-36 and ADAM at speeds of Mach 2.5 at over 56,000 feet.

TEST ITEM - The K-36D Ejection Seat

The K-36D ejection seat is designed by the Zvezda Design Bureau in Tomilino, Russia. The FSU ejection seat technology is strong in the integration of ejection seat subsystems such as windblast protection, leg and arm restraints, leg lifters, and a vented helmet which is designed to interface with the seat headrest. The K-36D and the flight equipment such as the pressure suit and helmet, were designed together as a single system. Incorporated into the seat are ballistically deployed telescoping stabilization booms with drogue parachutes. The telescoping booms are mounted near the top of the seat for rapid deployment insuring aerodynamic stability. Other subsystems that have been integrated into the total seat design include the windblast deflector, the rocket propulsion system, crew recovery parachutes, restraint tensioning devices, and sequencing systems. The seat's components and dimensions are shown in figures 4, 5, and 6.

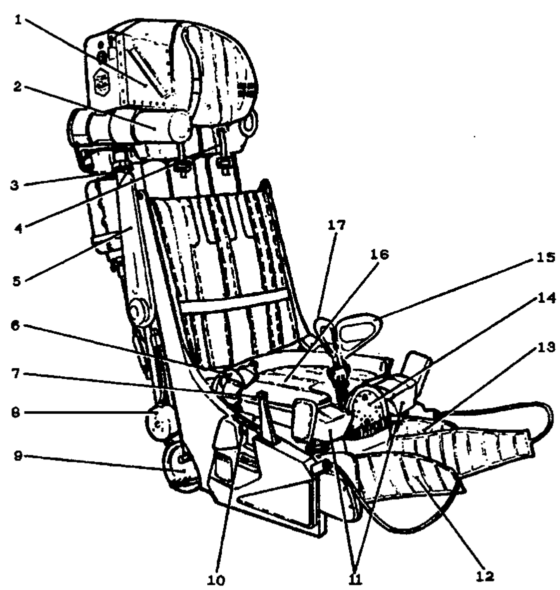


Figure 4. K-36DM Ejection Seat Components, Right Quarter View

1. Headrest
2. Telescoping Stabilization Boom
3. Stabilization Gas Cartridge
4. Shoulder Restraint Strap
5. Right Arm Paddle
6. Pelvic Restraint Strap
7. Manual Pelvic Restraint Adjustment Handle
8. Waist Restraint Mechanism
9. Propulsion Rocket Housing
10. Seat Vertical Adjustment Switch
11. Leg Lifting Mechanism
12. Right Leg Restraint Padding
13. Left Shin Cradle
14. Windblast Deflector
15. Ejection Initiation Handle
16. Padding
17. Fastening Strap

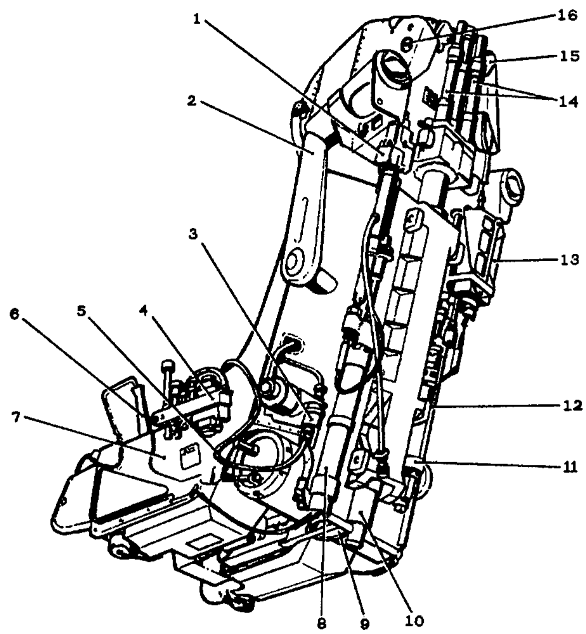


Figure 5. K-36DM Ejection Seat Components, Left Quarter View

1. Canopy Jettison Interlock Mechanism
2. Left Arm Paddle
3. Power Umbilical Connector
4. Combined Services Connector
5. Power Plug Cable
6. Shoulder Restraint Strap Locking/Adjustment Handle
7. K-36DM Ejection Seat
8. Catapult
9. Rocket Nozzle
10. Seat Propulsion Rocket
11. Restraint System Release Cartridge
12. Telescoping Boom Gas Cartridge
13. Parachute Deployment Control Unit
14. Parachute Deployment Gas Cartridge
15. Low Altitude Parachute Deployment Control Unit
16. High Altitude Parachute Deployment Control Unit

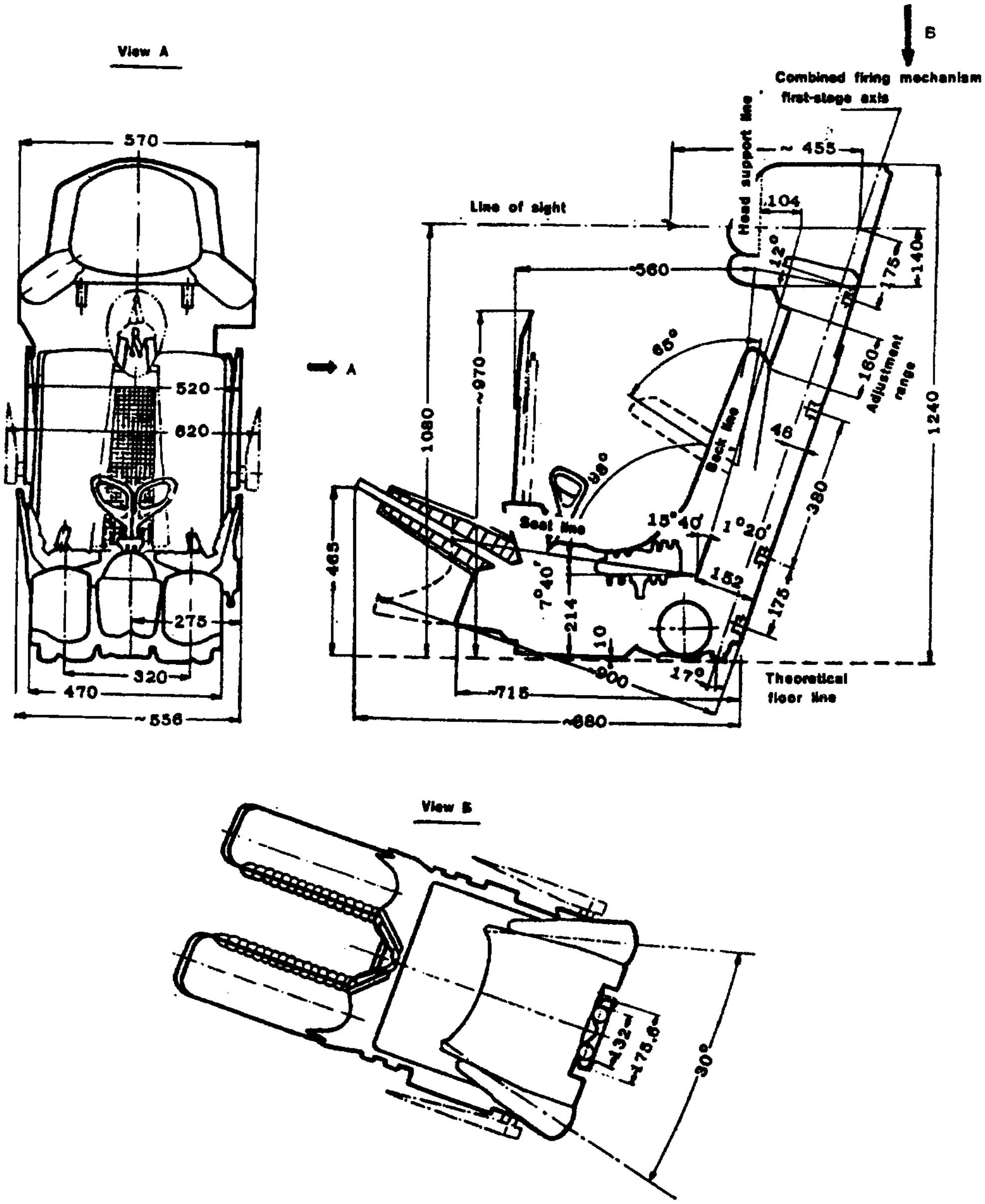


Figure 6. Ejection Seat Critical Dimensions

The K-36 occupant is attached to the seat by a seat mounted parachute and restraint harness during normal aircraft operations. A seat adjustment mechanism positions the crewmember for flight. The "design eye" position is maintained for each pilot by pre-positioning the seat in the cockpit so that the headrest is fixed and the seat bucket moves downward to accommodate different sized aircrew.

Performance Envelope

A K-36DM Series 2 was the ejection seat used in the test program. The Russian K-36DM ejection seat is advertised as an advanced ejection seat providing survival of the crewmember up to Mach 3.0 and altitudes of 80,000 feet. The K-36DM series 2 ejection seat is designed to ensure survival of the crewmember within a wide range of aircraft speeds and altitudes. The basic operating limitations of the seat depend on the flight gear used, the aircraft type, and flight conditions at the time of ejection.

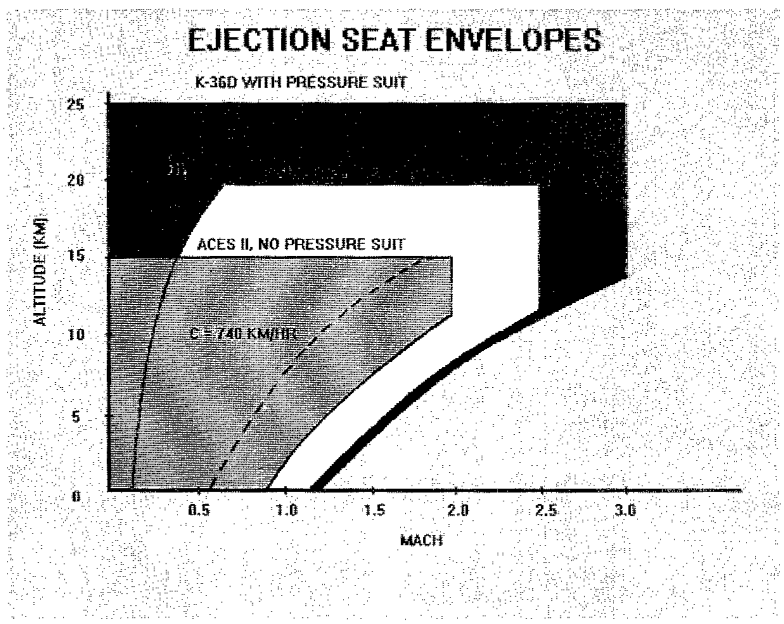


Figure 7. K-36D Seat Performance Envelope

Other versions of the seat include the K-36L, which is the lightweight, low speed seat. The L version has some of the windblast protection devices removed such as the windblast deflector. The K-36LV is a modified version of the L which was designed specifically for VTOL/VSTOL aircraft like the Yak-38. The LV version has an automatic ejection feature which is initiated if there is an aircraft failure which will cause departure from controlled flight during the vertical or near vertical phases of the flight regime. K-36LV features include a reinforced headrest specially designed to break through the canopy in case of aircraft failure during vertical takeoff or landing. The LV also has a supplemental pitch rocket which is automatically configured to forward, mid, or aft position, prior to an automatic ejection. The LV model functions similar to the L model during the conventional flight regime (i.e. no supplemental pitch rocket, canopy is jettisoned). The K-36RB is the ejection seat designed specifically for the Russian Buran Space Shuttle. This version operates in several modes which encompass the majority of the flight regime

such as launch pad ejection, accent phase, and decent and landing phase. The RB version includes a supplemental booster rocket and additional stabilization booms for launch pad ejection stabilization and trajectory control.

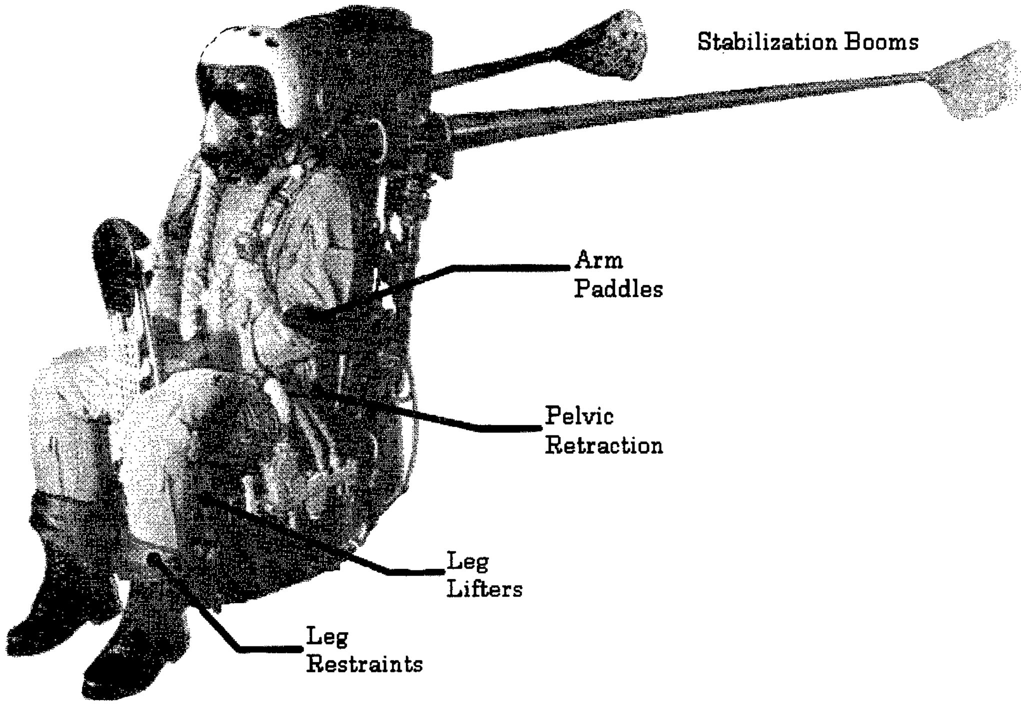


Figure 8. K-36D Ejection Seat Features

Technologies of Interest

Stabilization Booms

The stabilization booms assist in keeping the seat directionally stable from the time it separates from the aircraft until parachute deployment. The telescoping booms are installed at an angle of 15 degrees from the direction of seat flight and small drogue parachutes are stowed in the ends of the booms. As the seat moves up the aircraft guide rails during ejection, gases from a fired cartridge deploy the telescoping booms and drogue parachutes. The initiation of the boom deployment occurs when the seat has traveled between 13.8" to 23.6" depending on the type of aircraft in which the seat is installed. The boom segments extend under pressure, and as each boom segment is extended, it forms a seal at the end of the previous boom segment. The stabilization boom parachutes are deployed as a result of the inertia of the extending boom segments.

Restraint System

The crewmember ejection restraint system is seat mounted and it includes the upper torso restraint, pelvic restraint, arm paddles for upper limb retention, leg lifting mechanisms, padded leg straps (one per leg), and shin cradles. The restraint system confines the crewmember securely in the seat, and during ejection, positions the shoulders, pelvis, arms and legs. The shoulder restraint mechanism consists of two seat attachment points, each located five inches from the centerline of the seat. A mechanism is provided for manual locking during flight, as well as automatic restraint during maneuvering g-loads and retraction with locking during ejection. Connected to the harness are straps which are attached to the parachute risers.

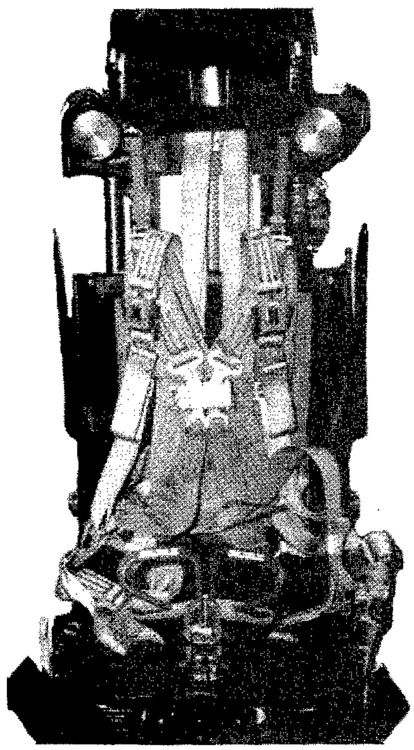


Figure 9. K-36D Restraint Harness

The lower harness straps are secured around the crewmember's legs, through rings on either side of the seat near the pelvis, and into a buckle near the center of the crewmember's chest. Adjustable pelvic restraint and automatic pelvic retraction occur during ejection. The pelvic restraint straps can be ratcheted tight or loosened by a handle located on the right side of the seat bucket. During ejection, the pelvic restraint straps are retracted by a cartridge actuated device.

Arm Paddles

The arm paddles provide rigid surfaces to react the arm forces generated during the ejection sequence. Right and left arm paddles are mounted on the upper sides of the seat frame. During ejection a cartridge-actuated device deploys the arm paddles. The paddles are first deployed outward. At maximum extension, the paddles rotate downward 65 degrees from their initial position. When this rotation is complete, the paddles are free to push inward towards the crewmember's arms and are prevented from moving outward by locking pawls. During separation of the seat, the arm paddles are released and are free to return to their initial stowed position.

Windblast Deflector

Additional protection against the aerodynamic loading experienced during high-speed ejection is provided by a seat-mounted, flat-plate deflector with a webbed apron. The catapult off-gasses provide pressure to deploy the windblast deflector. The windblast deflector is not deployed in low dynamic pressure situations (less than 430 KEAS). Above 430 KEAS and as a default mode the windblast deflector is deployed.

Helmet and Headrest

The headrest acts as a container for the parachute and altitude sensing devices and provides a concave padded support for the occupant's head/helmet. The helmet's outer shell is sized to fit within the headrest and has a series of holes across the top. The holes relieve the stagnation pressure that may develop during ejection. The stagnation pressure relief lowers the lift force acting on the head and helmet combination. The helmet visor is automatically lowered to provide additional protection.

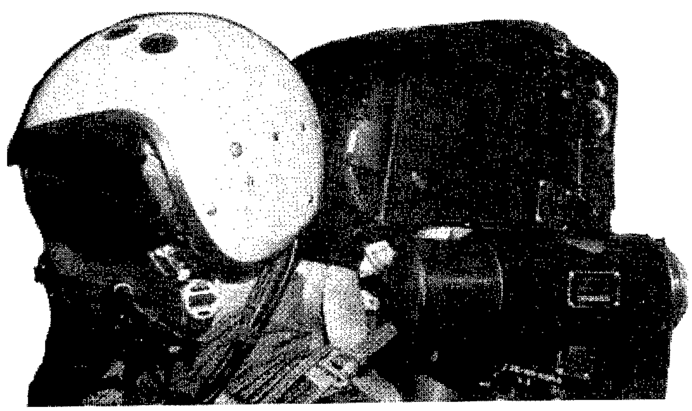


Figure 10. K-36 D Helmet/Headrest Interfacing

Leg Lifters

The Crewmember's legs are lifted and restrained during the ejection sequence. The lifting mechanisms and support cradles are mounted on the front of the lower seat frame and are deployed during the ejection. These are stowed during normal flight. The lower leg restraint lanyards are integrated with the cockpit and deployed during ejection. Lanyard cutters are provided to cut the restraint prior to parachute deployment.

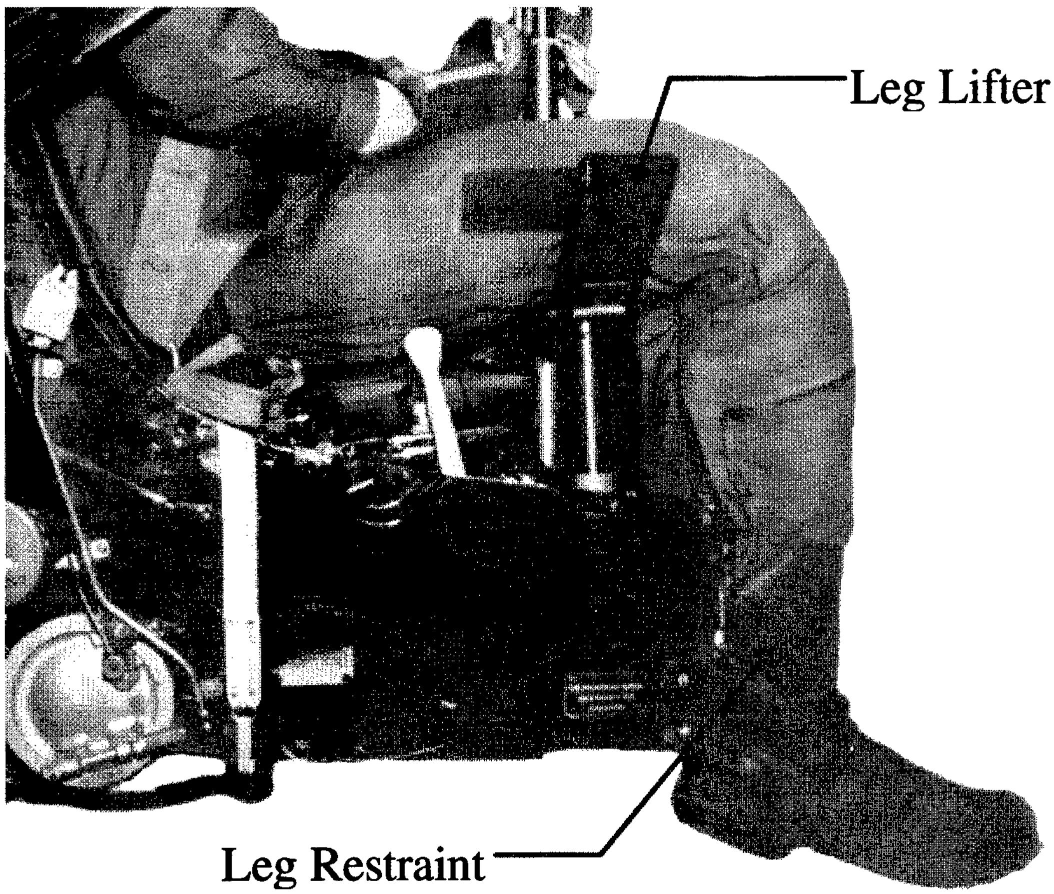


Figure 11. K-36D Leg Lifter and Leg Restraint System

Pyrotechnics

The K-36D ejection has the following pyrotechnics installed:

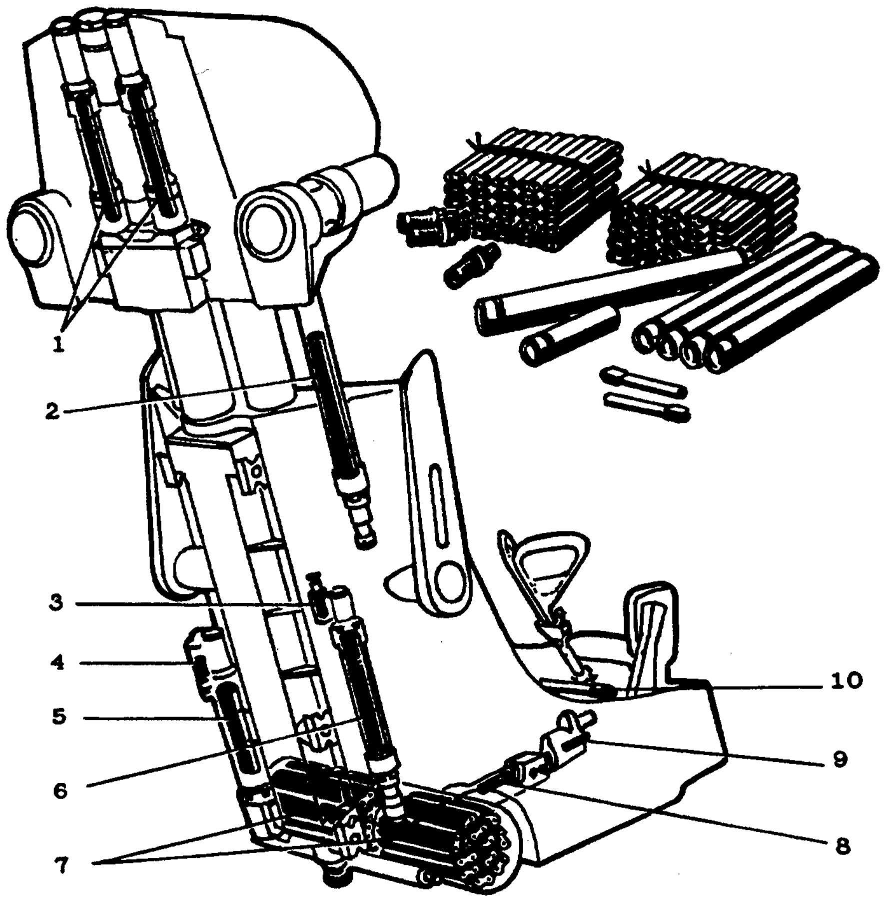


Figure 12. K-36D Pyrotechnics

1. Parachute Deployment Gun
2. Stabilization System (Booms) Deployment Gun
3. Restraint System Squib
4. Catapult Squib
5. Catapult
6. Restraint System Charge
7. Main Rocket
8. Main Squib Igniter
9. Windblast Deflector Valve Squib
10. Survival Kit Cutter Squib

Ejection Handles

The ejection handles consist of wire cable embedded within two polymer handgrips interconnected by a base, head with a ball retainer, and the actuating cable. The ejection handles are pivoted and locked forward during normal flight. During seat man separation, the handles are separated from the seat.

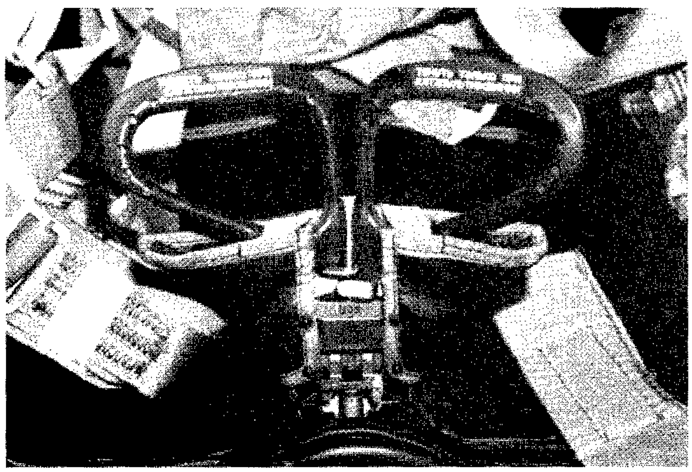


Figure 13. K-36D Ejection Handles

Parachute System

The parachute is a slot-type vented canopy with 28 rigging lines connected to the parachute risers. The parachute is projected in to airstream when the headrest is fired. At seat and crewmember separation, the arm restraints rotate back to their stowed position, the shoulder and waist restraint straps are severed, and the harness and crewmember are released from the seat. The K-36D receives its parachute deployment signal from the aircraft airspeed and two onboard altitude pressure/timing devices. These data are used to deploy the recovery chute at the proper time. The altitude at which the recovery chute is deployed is set (5,000 - 19,400 feet) prior to aircraft takeoff, depending on the geography of the region that the aircraft will be flying. If the aircraft is to be flying in a mountainous region, the recovery chute deployment is set for an altitude above the elevation of the mountains. If ejection occurs above the set altitude, the recovery chute does not deploy until it reaches that altitude. For altitudes between 5,000 and the set elevation, a fixed time delay of 4 seconds is used. For altitudes below 5,000 feet, the airspeeds at ejection determine the following approximate delays (from seat/rail separation) as shown in table 1.

V (KEAS)	0-367	400	500	600	690
delay, s	0.65	1.0	1.8	2.2	2.5

Table 1. Parachute Delay Times

General Operation

Ejection initiation is performed when the crewmember pulls the ejection handles located on the front of the ejection seat bucket. After ejection is initiated, canopy jettison and seat operation are automatic. The K-36D ejection seat has an inter-seat sequencing system which allows one crewmember to eject the other. Crewmember separation from the seat occurs as the shoulder, waist, leg and arm restraint systems are severed by restraint cutters. The parachute inflates automatically after seat and crewmember separation. The survival kit remains attached to the crewmember during descent. Figure 14 shows the operation and sequencing of the K-36D.

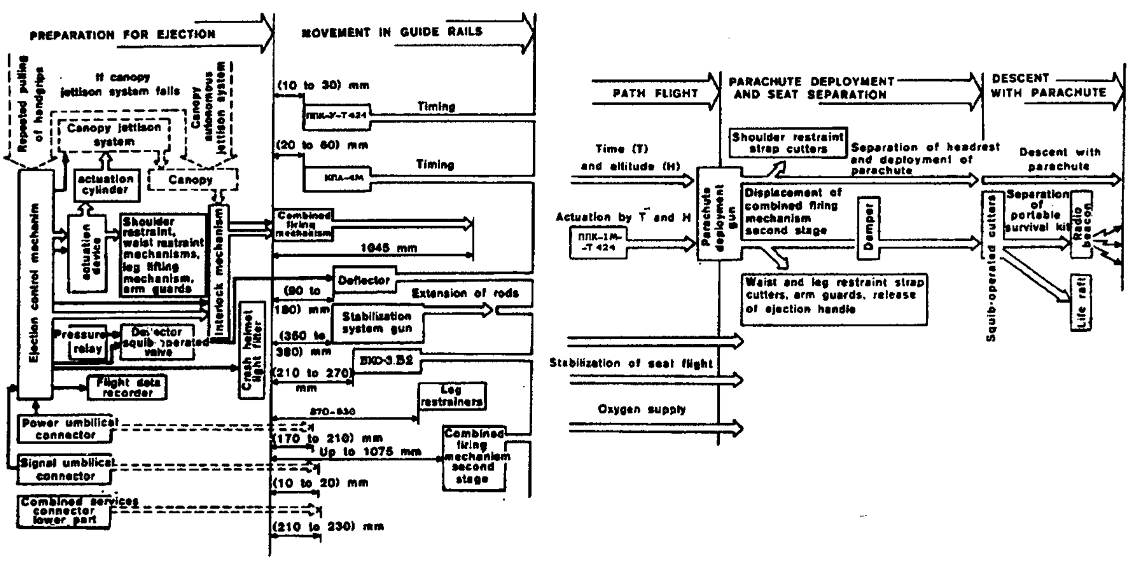


Figure 14. K-36D Operation and Sequencing

Seat Vertical Adjustment

The K-36D provides in the cockpit for the crewmembers with sitting heights between 32.3 inches and 38.6 inches. The crewmember's position in the seat is adjusted so that "design eye" is maintained. This position is indicated with markings on the padding of the headrest support. The seat adjustment range is 6.3 inches.

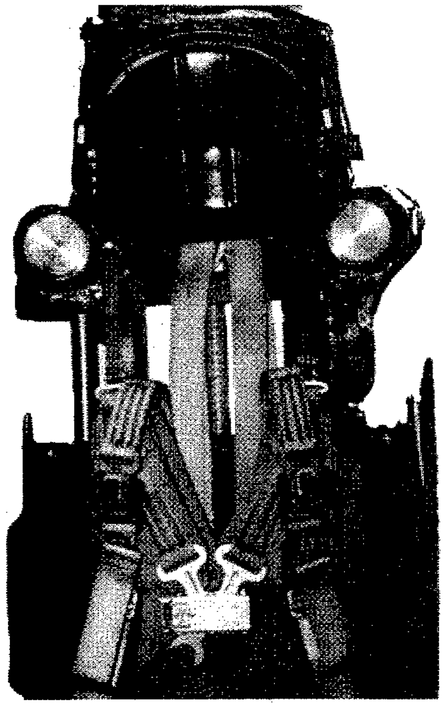


Figure 15. K-36D Vertical Adjustment Range

Oxygen System

A large connector provides a coupling to the crewmember's flight suit and the aircraft oxygen equipment, anti-g devices, suit ventilation system and electrical/radio equipment of the aircraft, as well as to the high-altitude suit with the necessary oxygen equipment. The oxygen equipment regulates pressure and oxygen flowrate supplied to the oxygen regulator for breathing and into the flight suit from the oxygen bottle during ejection, or in case of failure of the aircraft oxygen equipment. If the aircraft oxygen equipment fails, the oxygen system is engaged manually by the aircrew pulling the emergency oxygen handle.

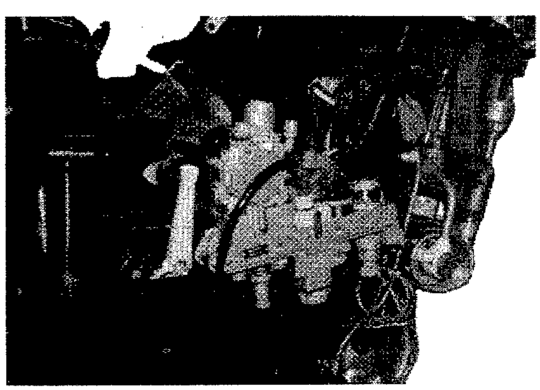


Figure 16. Combined Services Connector

METHODS, TEST EQUIPMENT, AND FACILITIES

Experimental Design

Traditional US ejection seat testing methodology consists of conducting both static (rocket sled with zero velocity) and rocket sled ejection tests with speeds ranging from minimal to maximum rated velocities of the test ejection seat. The use of rocket sleds, however, limit the testing to a single altitude and a fixed Mach number with respect to the velocity. Rocket sled testing cannot evaluate the Mach number effects or the changes in stability at high altitude, low static pressure conditions. In-flight ejection seat testing is available but the initial conditions at the time of ejection is limited.

Russian escape system test methodology, on the other hand, emphasizes testing the ejection seat at the corners of the ejection design envelope. The corners of the envelope include high-altitude/low-speed, high Mach number, and high dynamic pressure initial conditions. To achieve these conditions, the Russians use a modified MiG-25 which is referred to as the Flying Laboratory. In order to bridge the gap between Russian and US testing methodology and to obtain test data comparable to US tests, the test matrix consisted of a compromise between US and Russian testing. Three rocket sled tests were conducted to provide test conditions similar to those simulated in the US testing methods and to provide desired seat trajectory data. In addition, two in-flight tests were conducted at an altitude of approximately 4,000 ft ASL to obtain comparable altitude test data to that of the Holloman AFB high-speed test track. The high-speed features of the K-36 ejection seat were tested near the maximum dynamic pressure limits of the Flying Laboratory, with an emphasis on obtaining comparable dynamic pressures to the track tests and the low altitude Flying Laboratory tests.

The test program was conducted in two parts: the first part was referred to as the certification tests and second part was the high-speed ejection tests. The certification tests were conducted in May 1993. These included windblast and ejection tower tests of the manikin/seat combination. There were three primary objectives of these tests. The first was to verify the structural integrity of the equipment that would later be used in the high-speed rocket sled and MiG-25 in-flight tests. This equipment included the USAF ADAM manikin, the Russian developed SKIF manikin, the K-36 DM ejection seat, and associated Russian flight equipment. The second objective was to verify the correct operation of the test data recording systems. The US ADAM manikin and the Russian SKIF both had their own independently developed onboard data recording systems. The final objective was to insure comparability of data between the ADAM and SKIF manikins. The second

part of the program was the high-speed testing and it was accomplished in August-September 1993.

Zvezda's Big Vertical Catapult

Zvezda's Big Vertical Catapult (BVC) is an ejection tower similar to the US Navy Ejection Tower facility at Warminster, PA. The primary features of the Russian ejection tower include: 80 foot rail length set at an angle of 17° from the vertical; manual or electrical seat initiation; umbilical line for seat/manikin instrumentation or on-board data recorders; translating side cage for medical monitoring of subjects or subject evacuation. The tower is also man-rated for testing of human subjects. Six tests were conducted on BVC as part of the certification tests. Four tests were conducted using ADAM manikins and two tests were conducted using the Russian SKIF manikins. All six BVC tests were accomplished using K-36DM seats loaded with a full catapult charge.

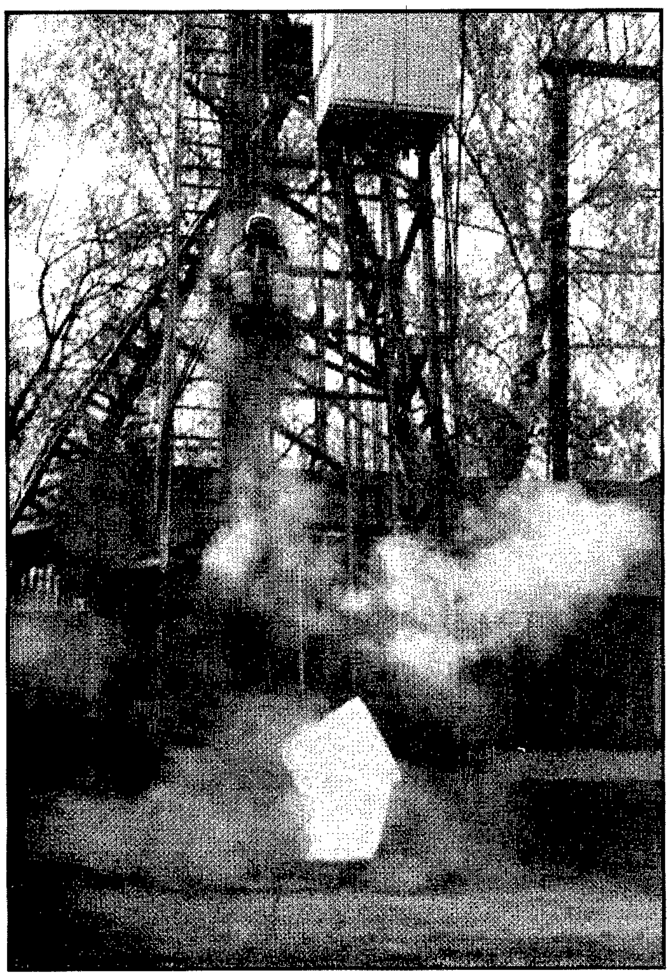


Figure 17. Big Vertical Catapult

Zvezda's Aerodynamic Facility

The Aerodynamic Facility is an open test section wind tunnel with capabilities that include a nozzle diameter of approximately 1.25 meter; maximum airflow velocity greater than 1400 km/hr, crewmember/seat translation (at 7-8 Gz acceleration) into the airflow from a sub-floor cavity to simulate ejection from a cockpit, airflow decay profile that approximates actual seat deceleration during windblast, one hour turnaround to recharge the windblast generator, and man-rating for human subject testing. A total of nine windblast tests were conducted as part of the certification tests. Test velocities varied from 1100 km/hr to 1420 km/hr. Four of the tests used the SKIF manikin, and five of the tests used the ADAM manikin.

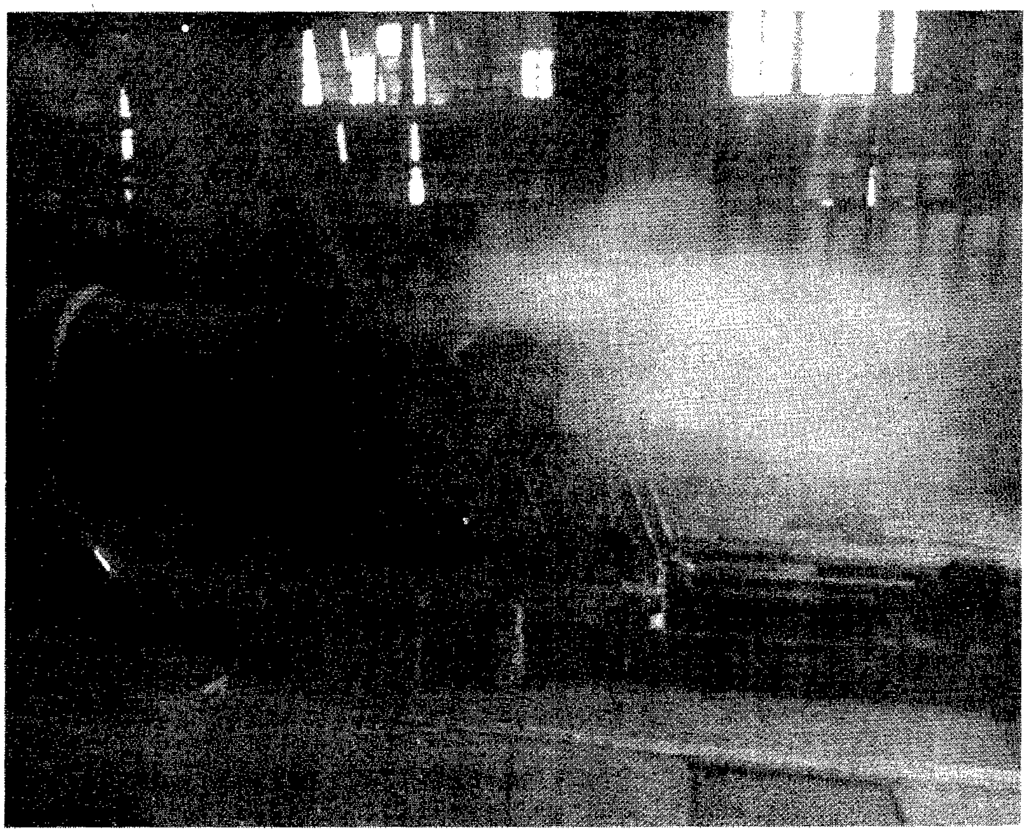


Figure 18. Aerodynamic Facility

High-Speed Rocket Sled Track

The rocket sled tests were conducted at the RD-2500 Rocket Track facility owned by the Beloziorsk Branch of GOSNIIAS (National Scientific and Research Institute of Aviation Systems). A Su-27 fighter forebody was fitted to the sled for the ejection seat tests. The track length is 2500 meters.

Figure 19. Rocket Sled with Su-27

Flight Institute of Aviation MiG-25 Flying Laboratory

The in-flight ejection tests were accomplished using the MiG-25 Flying Laboratory, owned and operated by the Gromov Flight-Research Institute. The Flying Laboratory is a modified MiG-25 that has the radome replaced with the pilot cockpit and the normal cockpit modified to fit an experimental, ejection-ready cockpit that includes a mock windscreen. The test sequence is initiated from this modified cockpit. The Flying Laboratory is equipped with six, on-board, wingtip cameras to record the initial portion of the ejection test event (fig X). In addition, a MiG-25 chase plane carries a photographer who records the initial portion of the ejection seat test. A radio beacon in the seat transmits its location back to the command control post where a computer monitor shows the location of the seat relative to the drop zone boundaries. The aircraft also transmits data to the command control post such as velocity, altitude, Mach number. The command control post computer display shows these parameters as well as the aircraft flight path, the calculated flight corridor, and the drop zone boundaries.

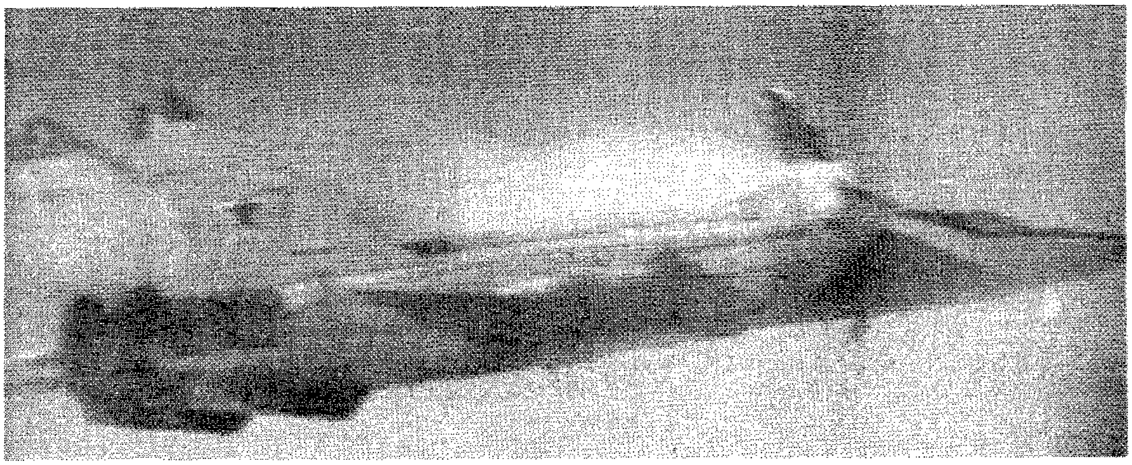


Figure 20. MiG-25 Flying Laboratory

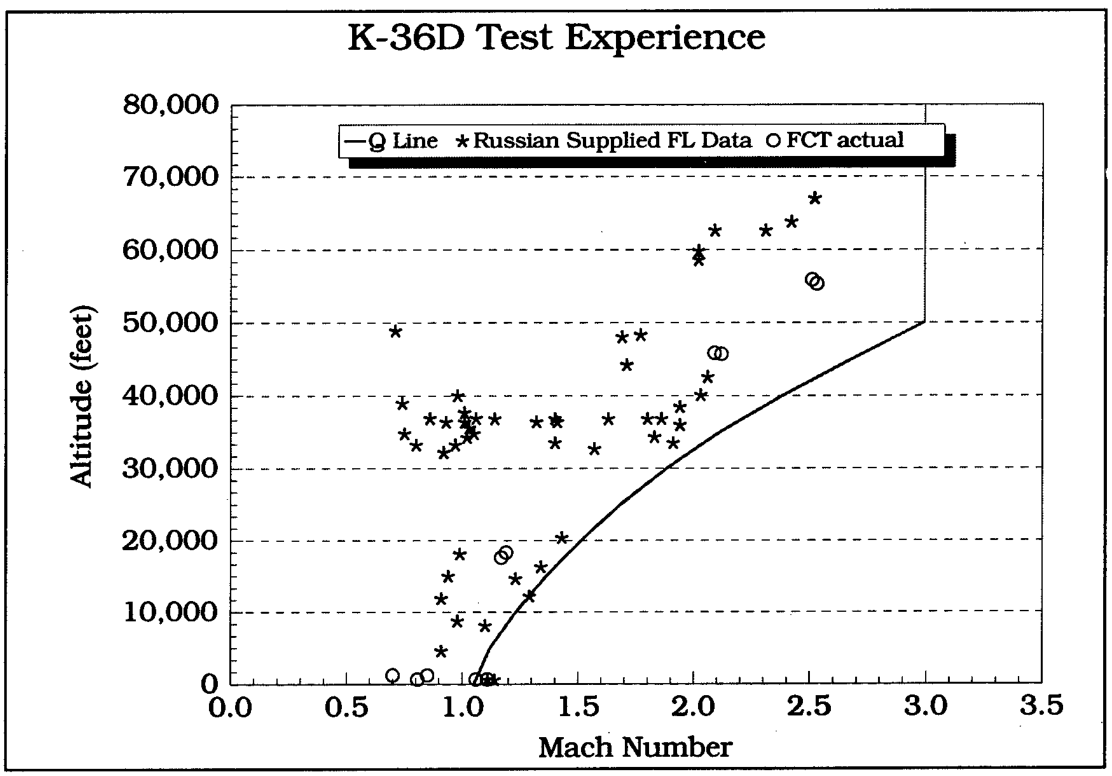


Figure 21. MiG-25 Flying Laboratory Test Experience

Manikins

ADAM

The Advanced Dynamic Anthropomorphic Manikin (ADAM) is a USAF developed manikin with improved human response characteristics and instrumentation capabilities that exceed those of the current escape system test manikins. A data acquisition system which was operated remotely with IBM compatible notebook computers was mounted within the manikin chest cavity.

Figure 22. ADAM

The ADAM Data Acquisition System (ADAS) was configured to collect electronic data from 64 channels at a maximum sampling rate of 10,000 samples per second for a period of 12.9 seconds. The ADAS contains 12-bit-resolution analog to digital converters, 12-pole anti-aliasing filters, shunt calibration, a fiber optic communication link, and NiCad rechargeable batteries.

Each ADAM was instrumented with the following sensors: linear accelerometers in all primary axes mounted in the head, chest, and lumbar regions, angular accelerometers mounted in the head and chest, six-component load cells mounted in the head/neck and at the base of the spine, position sensors mounted in the joints of the arms and legs, position sensors mounted in the hip, lower leg torque sensors, two load links to measure parachute riser loads, pressure sensors to measure total pressure acting on the manikins chest and helmet visor and a temperature sensor to measure the ADAS Internal Temperature.

Four ADAMs were used during the test program. Two large and two small manikins were prepared prior to the first high-speed ejection test. This allowed for a rapid manikin turnaround time as well as the *possibility* of simultaneous testing. The ADAM preparation commenced immediately after the certification testing and continued up to the first test.

SKIF

The Russian-made SKIF manikin was used in four high-speed ejection tests to gather comparable data to data that would be collected with ADAM. The SKIF manikin represents a 50th percentile Russian male pilot, and is constructed as a rigid segment manikin with a fiberglass exterior. The manikin contains an eight bit autonomous internal data acquisition system, capable of supporting 27 analog signals, 14 digital signals and 14 temperature signals. The SKIF data acquisition system is capable of sampling rates from 31 to 1000 Hz and sufficient memory to store 320 Kilobytes of data. It can store the collected data for 4000 hours.

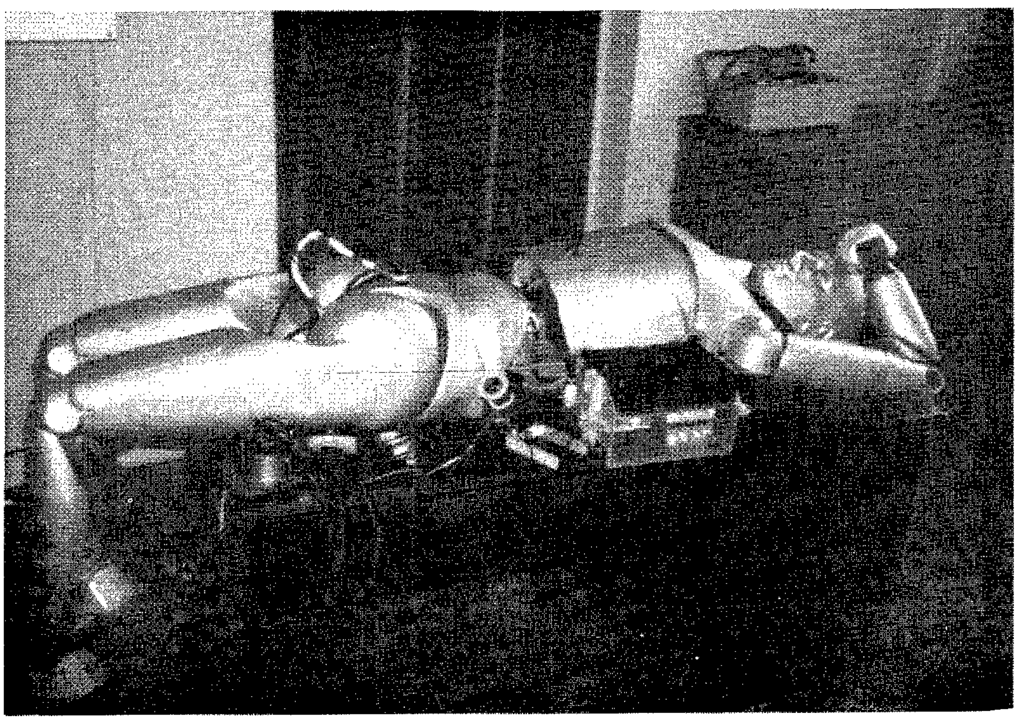


Figure 23. SKIF - Russian Ejection Test Manikin

Each SKIF was instrumented with the following Russian sensors: linear accelerometers in all primary axes mounted in the head and lumbar regions, neck load cell to measure tension/compression in the head and neck.

Data Acquisition

Coordinate System

The origin of the acceleration coordinate system is at the Seat Reference Point (SRP) and the Y-Z plane of the coordinate system (US) is the

compressed seat-back-tangent plane. Figure 24 shows the location, orientation, and coordinate system of the seat-mounted accelerometer bracket sensors with respect to the SRP. The Russian coordinate system is indicated in parentheses in the same figure. All terms referring to the coordinate system in this report are with respect to the US coordinate system.

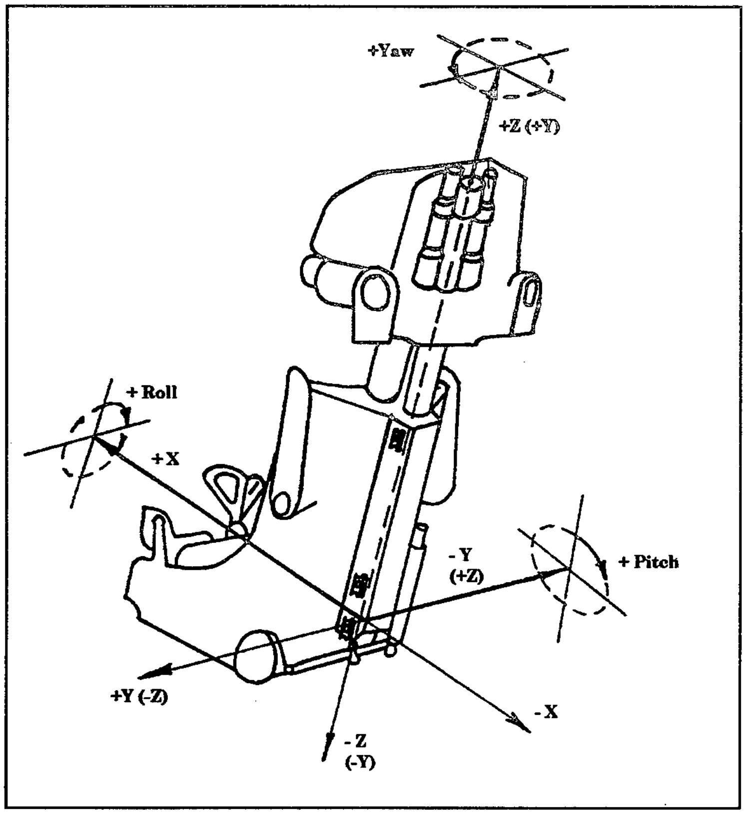


Figure 24. Seat Coordinate System

Sensors

A large number of sensors were required to ensure the collection of data to evaluate the K-36D. Since both the ADAM and SKIF manikins had completely different data acquisition systems, the sensors that were used with each manikin differed. To simplify the test program, each manikin was tested with the sensors and data acquisition systems designed for the manikin. Some of the sensors used with the ADAM were Russian supplied to allow for easy integration into the Russian flight equipment. These included load cells for the measurement of the arm loads and parachute riser loads. Ejection seat rail velocities were also recorded from a Russian supplied device and the signals were recorded with the ADAM software. Appendix A gives a summary of the US sensors.

Acceleration and Rates

The US instrumentation package included four tri-axial linear accelerometers to measure seat linear accelerations and three angular rate sensors to measure seat angular rates. These sensors were mounted to a Russian designed seat accelerometer mount bracket (see Figure 25). The accelerometer wires were routed out of the mounting area located in the lumbar area of the seat back and terminated at a connection which was plugged into the manikin data acquisition system. Accelerometers were also installed within the manikins. ADAM contained three chest-mounted linear accelerometers, three head-mounted linear accelerometers, three lumbar-mounted linear accelerometers, a head-mounted angular accelerometer oriented to provide angular accelerations about the y-axis, and a chest-mounted angular accelerometer oriented to provide angular accelerations about the y-axis

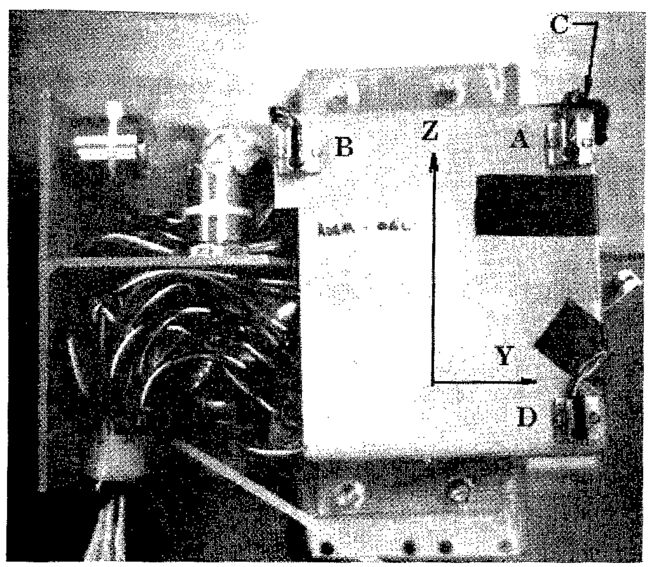


Figure 25. Accelerometer Mounting Bracket

Forces and Moments

Load cells were also mounted within ADAM for the measurement of forces and moments in six degrees of freedom in the neck and also in the lumbar region of the manikin spine. Figure 26 shows the coordinate system for these load cells. Load cells were also installed in the legs to measure the forces generated during lower leg rotation.

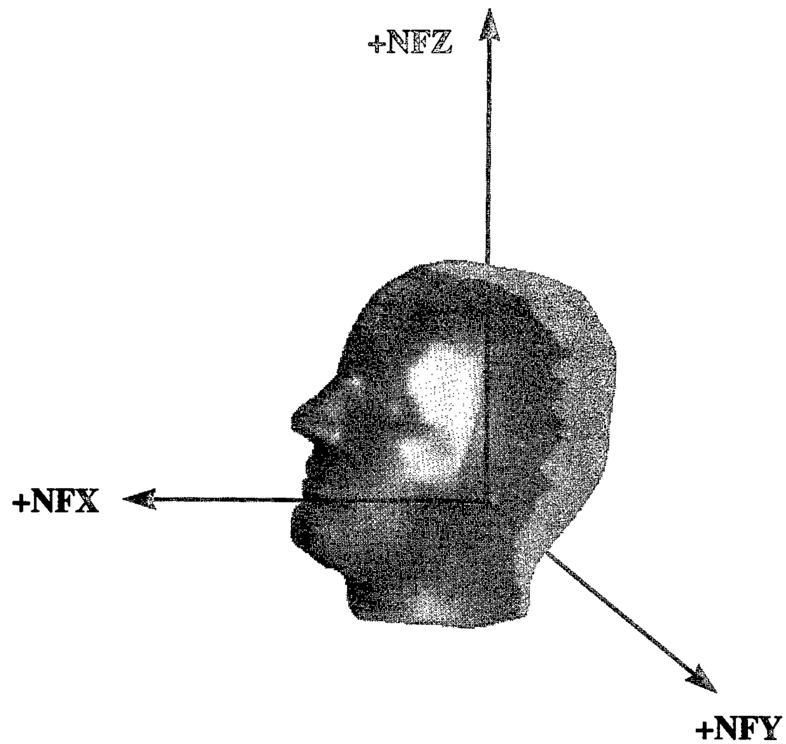


Figure 26. Neck and Lumbar Coordinate System

Pressures

Total pressures of the local windstream were measured at the following locations: front of windblast deflector, top of windblast deflector, harness buckle located near the center of the manikin's chest, the center of the helmet visor, and at a location internal to the ADAM manikin torso cavity. Both absolute and sealed gage pressure transducers were used. The type of pressure transducer that was used varied with the differing ejection conditions.

Parachute Risers

Total tension forces acting in the parachute risers were measured using load cells which replaced the harness connection with the parachute risers. The load cells were manufactured and supplied by Zvezda.

Ejection Seat Separation Rail Velocity

The K-36 ejection seat and rail separation velocity was obtained using an electro-magnetic interrupter device. An inductive coil which moved with the ejection seat was placed on a cockpit mounted rail containing magnetic material. The magnetic material was positioned at 10

cm increments. When the coil passed over the magnetic material, an electrical signal was produced and was recorded with the data acquisition system. The velocity was calculated by taking the distance that separated the magnetic material and dividing it by the time between each electrical pulse. These average velocities could then be plotted against either distance or time from ejection initiation. The velocity at the end of the rail length was determined from either of these plots.

Significant Ejection Events

Significant ejection events were recorded with the ADAM DAS. The seat events recorded were seat first motion, stabilization boom deployment, parachute headbox deployment, and seat and manikin separation.

Photogrammetry

For all sled tests, the test facility provided optical reference markings on the forebody. The sled ejection seat/manikin trajectories were tracked by following the approximate visual center of the seat/manikin combination until seat/manikin separation, after which only the manikin was tracked. Events such as seat separation and seat first motion, canopy separation and canopy first motion, parachute line stretch, parachute first full inflation, etc., were determined from these tracking films. The Russian test personnel used trajectory camera coverage to tabulate and plot displacements and velocities of the K-36 and manikin combination from seat initiation to seat/manikin separation, and at seat/manikin separation, the location of the manikin was plotted. The Russian test personnel were responsible for providing all photogrammetrical data to the US engineers. This data was provided to the US in the form of test reports and films.

DATA PROCESSING

Nomenclature and Symbols

See **ABBREVIATIONS** and Appendices B and C for a complete list of nomenclature and symbols relating to data.

Data Reduction

Unprocessed data for each test were plotted immediately after the test data was downloaded to the portable PC. The plots were examined for channel functionality, continuity, and amplitude. The data was then filtered and the critical time was plotted for each channel. The high-speed ejection tests were processed for three time phases of the ejection sequence. These phases were 1) from ejection seat initiation to ejection seat and aircraft or forebody rail separation, 2) from ejection seat and aircraft or forebody rail separation to seat and manikin separation, and 3) after seat and manikin separation. Maximums and minimums of data for each phase were determined and recorded in tables 10, 11, and 12. The data was further reduced to highlight various aspects of seat and manikin performance.

Digital Filtering and Reduction

The raw data which were collected at sample rates up to 10,000 Hz, were filtered, reduced and plotted. The filter cut-off frequencies depended upon the data channels being filtered. All limb data were with a 5-pole Butterworth filter at 10 Hz, pressure data were filtered at 20 Hz, the rail velocity was unfiltered, and all other channels of electronic data were filtered at 100 Hz. A sample of the processed data plots are contained in Appendices G and H. The processed data plots include final data plots plus any re-scaled plots.

Minimum and Maximum Values

The minimum and maximum values and the corresponding times of the processed electronic data were determined and tabulated for every channel, for each ejection phase. These phases were 1) from ejection seat initiation to ejection seat and aircraft or forebody rail separation, 2) from ejection seat and aircraft or forebody rail separation to seat and manikin separation, and 3) after seat and manikin separation.

Evaluation Criteria

DRI and Radical

The Dynamic Response model for the Z-axis (DR_Z) was used to evaluate the potential for spinal injury while the K-36D was in contact with the ejection seat rails. During this phase of ejection, the majority of the seat acceleration is produced from the thrust of the catapult and is directed primarily along the axis of the spine. A DR_Z value of 18 corresponds to a probability of spinal injury of 5 percent for Air Force flying personnel. A DR_Z value of 22.8 corresponds to a probability of spinal injury of 50 percent. The DR_Z model as stated in the Air Force Specification Guide (AFSG) - 87235A was modified to include more recent data for human response to $-G_Z$ acceleration.

A second acceleration index was used to evaluate the acceleration environment of the ejecting crewmember. This index is a mathematical expression which is used to evaluate the acceleration environment of the crewmember between the time of seat and aircraft separation, to the time of seat and crewmember separation. This expression is referred to as the multi-directional acceleration radical (radical). The radical is stated as

$$\sqrt{\left(\frac{DR_Z(t)}{DR_{Z_L}}\right)^2 + \left(\frac{G_X(t)}{G_{X_L}}\right)^2 + \left(\frac{G_Y(t)}{G_{Y_L}}\right)^2} \leq 1.0$$

where:

DR_Z is the Dynamic Response computed from the z-axis acceleration component at the accelerometer location.

G_Y is the y-axis acceleration component at the accelerometer location.

G_X is the z-axis acceleration component at the accelerometer location.

The subscript L denotes the limiting value of DR_Z and that of the x-and y-axes.

The general risk of injury is calculated based on the DR_Z values for the z-axis and linear acceleration values for the x-, and y-axes, and the established limit values as described in AFGS - 87235A.

Head Forces

The head and neck measured forces were compared to the load limits specified in the CREST Statement-of-Work (Ref x) and the Naval Biodynamics Laboratory (NBDL) Guidelines for Safe Human Impact Exposure. These limiting values are listed in Table 2. The limiting values listed from the NBDL Guidelines are shown in two categories. The first represents the limit currently used for safe human impact exposure on the NBDL impact facilities for force pulse duration greater than 45 milliseconds. These force levels do not produce injury but indicate the force levels that human subjects have reported discomfort to the point of not wanting to continue. The second row of values represent data taken from tests with cadavers. The cadavers were autopsied after the exposure to impact and were found to have no ligament failure or bone damage at these determined force levels. The levels are based on un-embalmed cadaver responses with the chin in contact with the chest.

Criteria\Force (lbs)	+Fz	-Fz	Fy	+Fx	-Fx
CREST	**300**	-	50	-	-
NBDL(>45mSec)	255	**250**	**90**	**189**	**189**
NBDL(cadaver)	551	400	-	437	437
Lit. Search, Low	194	135	154	189	189
Lit. Search, High	400	674	418	337	337

Table 2. Neck Force Criteria

Hand Loads

The criteria used for determining the ability of the crewmember during the ejection event was obtained from Horner, et al. Grip strength retention curves were generated for the adult male population when using a variety of grip configurations. The probability of letting go was estimated for the subject population for each grip configuration. A twin grip, which is similar to the ejection handle used on the K-36D, was determined to be the most effective arrangement for grip strength. The force curves generated from this data were used in comparison with the total arm forces measured during the test program.

Leg Loads

The ADAM lower leg load cell measures the force produced by tibular rotation induced by aerodynamic loading on the manikin's feet. This force, when multiplied by the moment arm between the center of rotation and the load cell, yields the lower leg torque. Grood, *et al,* developed design limits

for lower leg rotational torque. The range of ligament failure is listed in table 3 below.

	External (-)		Internal (+)	
Failure Range	Low	High	Low	High
Torque (in*lb)	478.8	550.8	392.4	778.8

Table 3. Ligament Failure of Knee

Limb Rotations

Limb rotations were noted in cases where they had reached the limit of rotation for each individual joint. See Appendix E for a summary.

Parachute Loads

Maximum parachute opening loads were compared to an industry accepted standard of 25 G's. The Dynamic Response for the z-axis was calculated using the z-axis acceleration. A value of 18.0 or less is considered acceptable.

CONDUCT OF TESTS

Safety

The K-36D comparative test and evaluation program was conducted in compliance with established Russian test facility safety requirements.

Procedures

Sensor Calibration

All US linear and angular accelerometers and rate sensors were dynamically calibrated in the US by Dyncorp at the Armstrong Laboratory immediately prior to the beginning of the ejection testing. The leg, neck, and lumbar load cells were calibrated by SRL prior to the shipping of the ADAM manikins to Russia. Newly purchased pressure transducers were calibrated by the manufacturer and check loaded by SRL. All Zvezda sensors were calibrated by Zvezda.

Manikin Preparation

The manikin preparation, data acquisition setup, and post-test inspection was accomplished by the test facility when using the SKIF manikin. When an ADAM manikin was used, these functions were performed by the US engineers on-site. After manikin assembly and dressing, instrumentation checks of the ADAS was performed.

The parachute load cells were installed in place of the operational restraint connectors so that parachute performance was not compromised with the addition of the load measuring device. With these force measuring devices, the main recovery parachute riser loads were measured for each riser. The Russian test personnel were responsible for the mounting and integration into the K-36 personal recovery parachute.

The test-ready manikin was installed in the test-ready seat and connected to sensors previously mounted onto the K-36 ejection seat. A facility pre-test resistance calibration was performed and the values were examined for reasonable magnitudes.

Seat Preparation

A mounting bracket for linear accelerometers and angular rate sensors were installed inside the seat structure behind the lower seat back.

For this installation, certain pressure tubes of the seat restraint pyrotechnics were removed. A transducer to measure seat/rail motion velocity was mounted outside the seat structure.

The seat initiation system was connected directly to the sled control system through special wiring. The normal mechanical device that is operated when the ejection handle is pulled, was disabled for these tests. The manikin data acquisition system was operated through the wiring of the combined services connector mounted on the K-36D ejection seat. Mounting brackets for the seat/manikin umbilical connectors were installed on the seat side panels. The seat recovery parachute was packed in the seat pan instead of a survival kit. The instrumented manikin suited in the KKO-15 (or in the high-altitude tests, the KKO-5) protection gear was fixed in the seat by the body restraint harness system.

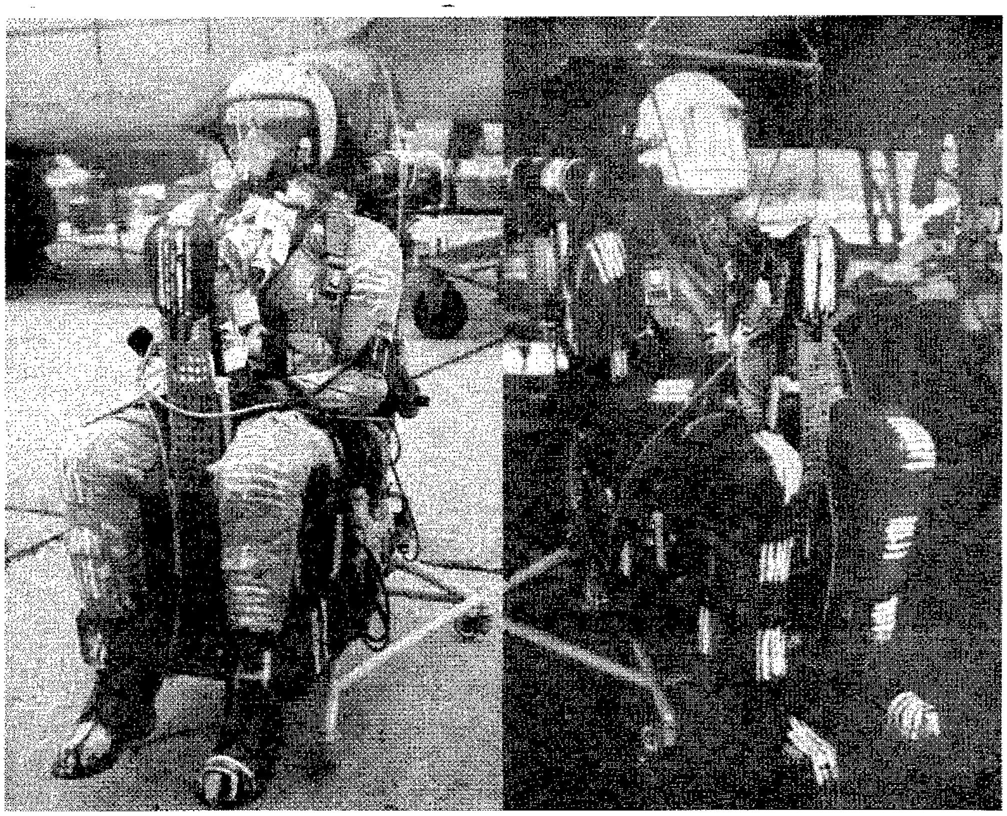


Figure 27 - KKO-15 Flight Suite (left) and KKO-5 Flight Suite

Since the measurement of K-36D performance data at high-speed was the primary objective of the test program and not subsystem reliability, several subsystems of the ejection seat were pre-deployed

The K-36D ejection seat was modified in the following manner to insure the collection of high-speed performance data and meet safety standards for the facilities involved. The windblast shield was extended prior to the test and locked into position. The suited manikin was restrained in the seat manually. This meant that the arm arresting paddles were lowered and manually locked in place, leg elevators were placed in their full upright position, shoulder and waist restraint belts were retracted up to their stop position, leg restraint lanyards were retracted up to their stop position and locked. The helmet visor was lowered and locked. The manikin hands on the SKIF were linked to the ejection grip handle with a belt (the ejection grip handle is automatically released during seat and man separation). During the ADAM high-speed tests, the hands of the manikin were removed and replaced with force measuring load cells which were attached to the ejection grip handle with a strap; the ejection grip handle was pulled into the "initiated" position.

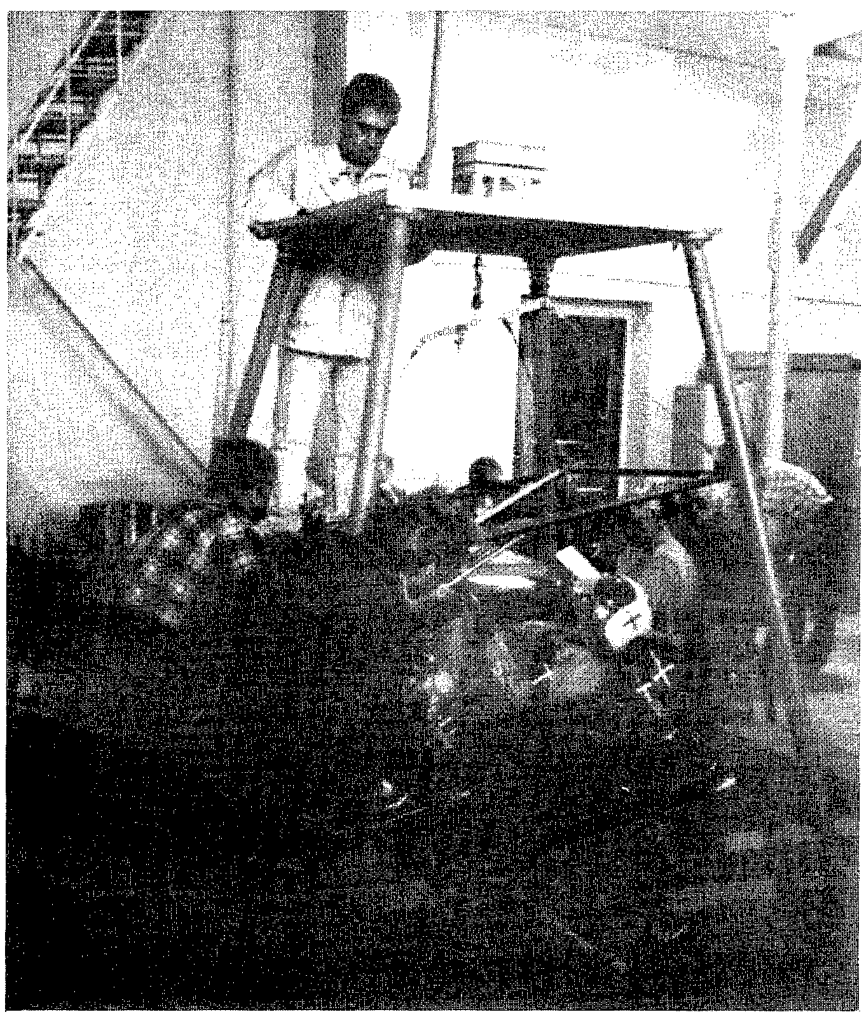


Figure 28 - Weight and Center of Gravity Device

Prior to installation in the cockpit, the seat and manikin weight, CG location and moments of inertia (Ix, Iy, Iz, Ixy, Ixy, Iyz) were measured. For this procedure, mock-ups of pyrotechnics with proper weight representative elements were installed in the seat subsystems. The seat elements which remain in the plane after ejection (telescopic gun inner tube with drives to initiate stabilization booms and barometric time delay mechanisms, lower parts of the combined services connector and umbilical connectors) were removed from the seat prior to making the measurements.

The pressure altitude time delay mechanisms were set to time delay and altitude corresponding to desired initial ejection conditions and to facilitate seat and manikin recovery after a test. Parachute opening was delayed in the high-altitude tests so that it would occur at 1000m to help recovery crews sight the test articles.

After these activities were performed, the seat was installed in the rocket sled forebody or in the MiG-25 Flying Laboratory. The seat systems were checked and armed.

Instrumentation Check-out/Arming

Prior to arming the Data Acquisition System, continuity checks were run on all sensors. Data were collected in pretest runs to insure that the DAS was functioning properly. R-CAL's were taken and immediately prior to the test and the system was armed.

Data Download

Immediately upon retrieving the ADAM manikin, the DAS was powered up, checked out, and the data was downloaded to the laptop personal computer (pc).

Test Classification/Success Criteria

A "No Test" was defined as the K-36 or the instrumented manikin failing to operate as a result of:

1) A malfunction not related to the K-36 (such as failure of the test initiation system, improper rigging, etc.).

2) Manikin, ADAS, or K-36 malfunction due to improper assembly, maintenance, test preparation, or operation.

3) The test conditions (i.e., sled velocity (+25 KEAS/-10%), sled acceleration at ejection, high winds) are not within acceptable ranges.

A "Failure" was to declared if the K-36 failed to perform as specified in supplied K-36 seat performance documents.

A "Test Objective Failure" was to be declared if inadequate data were collected to determine the performance of ejection seat or ejection seat subsystems.

Any test not classified as a "No Test", "Failure", or "Test Objective Failure" was determined to be an "Acceptable" test. All tests were determined to be acceptable.

Test Conditions

All data were collected at the experimental conditions specified in Table 4. Russian test personnel were responsible for determining if environmental factors such as snow, humidity, temperature and windspeed

#	EQUIVALENT AIRSPEED KEAS(km/h)	MANIKIN	EQUIP	ALT ASL (km)	FACILITY
1,2	0	SKIF	KKO-15	GL	BIG VERTICAL CATAPULT
3,4,5	0	Small ADAM	KKO-15	GL	BIG VERTICAL CATAPULT
1	610 (1130)	SKIF	KKO-15	GL	AERODYNAMIC FACILITY
2	697(1290)	SKIF	KKO-15	GL	AERODYNAMIC FACILITY
3	697 (1290)	SKIF	KKO-15	GL	AERODYNAMIC FACILITY
4	605 (1120)	S-ADAM	KKO-15	GL	AERODYNAMIC FACILITY
5	705 (1305)	S-ADAM	KKO-15	GL	AERODYNAMIC FACILITY
6	767 (1420)	SKIF	KKO-5	GL	AERODYNAMIC FACILITY
7	756 (1400)	S-ADAM	KKO-5	GL	AERODYNAMIC FACILITY
8	594 (1100)	S-ADAM	KKO-15	GL	AERODYNAMIC FACILITY
9	702 (1300)	S-ADAM	KKO-5	GL	AERODYNAMIC FACILITY
1	567 (1050)	Small ADAM	KKO-15	656 (0.2)	ROCKET SLED
2	700 (1295)	Large ADAM	KKO-15	656 (0.2)	ROCKET SLED
3	755 (1400)	SKIF	KKO-5	656 (0.2)	ROCKET SLED
4	450 (833)	Large ADAM	KKO-15	4,000(1.2)	FLYING LAB
5	600 (1110)	SKIF	KKO-15	16,400(5)	FLYING LAB
6	600 (1110)	Small ADAM	KKO-15	16,400(5)	FLYING LAB
7	567 (1050)	Large ADAM	KKO-15	4,000(1.2)	FLYING LAB
8	600 (1030)	SKIF	KKO-5	37,600(11.5)	FLYING LAB M=2.0
9	600 (1030)	Large ADAM	KKO-5	37,600(11.5)	FLYING LAB M=2.0
10	550 (975)	SKIF	KKO-5	50,740(15.5)	FLYING LAB M=2.5
11	550 (975)	Large ADAM	KKO-5	50,740(15.5)	FLYING LAB M=2.5

Table 4. Test Configuration Data

would prevent a scheduled ejection from taking place. No environmental factors caused the delay of any tests.

The manikin type and size used for each ejection is also listed in Table 4. Each manikin was outfitted with either standard Russian flight suit equipment (KKO-15) or the Russian Complex full pressure suit and equipment (KKO-5).

TEST RESULTS

Certification Tests

Aerodynamic Facility

The test conditions and summaries of critical maximum and minimum manikin loads are listed in Table 5.

Big Vertical Catapult

The summaries of critical maximum and minimum manikin loads are listed in Table 6.

High-Speed Ejection Tests

Test Conditions

The test conditions for the high-speed rocket sled tests and the in-flight tests are shown in Table 7.

Event Timing

The critical event timing is shown in Table 8.

Dynamic Test Results

The summary of test results from the high-speed rocket sled tests and the in-flight tests from seat initiation to seat and rail separation are listed in Table 9. The summary of test results from seat and rail separation to seat and manikin separation are listed in Table 10. The summary of test results after seat and manikin separation are listed in Table 11.

Manikin Limb Positions

Manikin limb position summaries are listed in Table 12.

Test	Manikin	Speed KEAS (km/hr)	Min/Max Neck Fx (lbs)	Min/Max Neck Fx (kg)	Min/Max Neck Fz (lbs)	Min/Max Neck Fz (kg)	Max Left Grip (lbs)	Max Left Grip (kg)	Max Right Grip (lbs)	Max Right Grip (kg)	Remarks
1	*SKIF*	*610 (1130)*	-	-	*-173.1/466.0*	*-78.7/211.8*	*NM*	*NM*	*NM*	*NM*	
2	*SKIF*	*697(1290)*	-	-	-	-	*NM*	*NM*	*NM*	*NM*	*Manikin failure*
3	*SKIF*	*697 (1290)*	*-1.3/125.9*	*-0.6/57.2*	*-18.4/85.8*	*-8.4/39.0*	*NM*	*NM*	*NM*	*NM*	
4	S-ADAM	605 (1120)	-63.0/127.8	-28.6/26.0	-112.0/386.9	-50.9/175.9	69.9	31.8	20.4	9.3	
5	S-ADAM	705 (1305)	-91.6/320.7	-41.6/145.8	-175.0/598.1	-79.5/271.9	113.8	51.7	87.6	39.8	Data Spikes
6	*SKIF*	*767 (1420)*	*-164.8/109.3*	*-74.9/49.7*	*-113.5/90.4*	*-51.6/41.1*	*NM*	*NM*	*NM*	*NM*	*Leg restraint failure*
7	S-ADAM	756 (1400)	-106.8/75.5	-48.5/34.3	-212.7/273.6	-96.7/124.4	147.9	67.2	93.7	42.6	Data Spikes
8	L-ADAM	594 (1100)	NM	NM	NM	NM	NM	NM	NM	NM	Structural Test
9	L-ADAM	702 (1300)	NM	NM	NM	NM	NM	NM	NM	NM	Structural Test

Table 5. Aerodynamic Facility Results

Test	Manikin	Max Neck Fx (lbs)	Max Neck Fx (kg)	Max Neck Fz (lbs)	Max Neck Fz (kg)	Max Seat Gz	Max Seat DRZ
1	S-ADAM	-45.2/202.7	-20.5/92.1	-230.2/131.7	-104.6/59.9	15.7	18.1
2	S-ADAM	-23.8/183.6	-10.8/83.5	-177.7/117.6	-80.8/53.5	13.6	15.9
3	S-ADAM	-29.9/175.1	-13.6/79.6	-156.1/103.4	-71.0/47.0	12.7	14.9
4	*SKIF*	*-9.5/44.5*	*-4.3/20.2*	-	-	*12.9*	*15.3*
5	*SKIF*	*-9.5/50.7*	*-4.3/23.0*	*-32.6/44.5*	*-14.8/20.2*	*12.1*	*14.3*
6	L-ADAM	N/A	N/A	N/A	N/A	N/A	N/A

Table 6. Big Vertical Catapult Results

Test Number	1	2	3	4	5	6	7	8	9	10	11
Test Date	8/18/93	8/25/93	8/27/93	8/27/93	8/30/93	8/31/93	9/3/93	9/9/93	9/9/93	9/14/93	9/16/93
Designation	FL110005	SL1400	FL110005	FL083301	FL105001	SL1050	FL103012	FL103012	FL097516	FL097516	SL1295
Seat Serial Number	822H92670	822H92700	822H92683	822H92694	822H92677	822H92688	822H92695	822H92680	822H92690	822H92675	822H92699
Manikin	SKIF	SKIF	Small ADAM	Large ADAM	Large ADAM	Small ADAM	SKIF	Large ADAM	SKIF	Large ADAM	Large ADAM
KEAS	551	729	545	451	545	532	508	510	483	483	694
Airspeed (km/hr) (ft/sec)	1020 930	1350 1230	1010 920	836 762	1010 920	985 898	940 857	945 861	895 816	895 816	1285 1171
Mach Number	1.16	1.11	1.19	0.71	0.85	0.81	2.09	2.10	2.50	2.50	1.08
Incompressible Dynamic Pressure (psf) (Pa)	1027 49173	1799 86136	1007 48215	690 33037	1007 48215	958 45869	872 41751	881 42182	791 37873	791 37873	1630 78045
Compressible Dynamic Pressure (psf) (Pa)	1419 67942	2428 116253	1419 67942	780 37346	1206 57743	1128 54009	2285 109406	2323 111225	3060 146513	2912 139427	2160 103421
Altitude - Geometric (ft) (m)	17585 5360	656 200	18289 5576	1230 375	1203 367	656 200	45673 13921	45660 13921	55283 16850	55825 17020	656 200
Altitude - Pressure (ft) (m)	17487 5330	699 213	19094 5820	2100 640	1821 555	328 100	46588 14200	46522 14180	56168 17120	56102 17100	778 237
Crewmember Equipment	KKO-15	KKO-5	KKO-15	KKO-15	KKO-15	KKO-15	KKO-15	KKO-15	KKO-5	KKO-5	KKO-15
Ejected Weight (lbs) (kg)	462.2 210.07	463.5 210.70	411.1 186.85	487.4 221.55	488.3 221.95	412.0 187.29	461.6 209.80	492.7 223.95	464.0 210.89	494.5 224.75	490.4 222.90
Weather Conditions	Clear	Clear	Prt Cloudy	Prt Cloudy	Prt Cloudy	Cloudy	Clear	Cloudy	Cloudy	Rain	Cloudy
Temperature (ºF) (ºC)	3.2 -16.0	59.7 15.4	-9.4 -23.0	51.8 11.0	50.7 11.6	50.7 10.4	-70.6 -57.0	-70.6 -57.0	-70.6 -57	-70.6 -57	44.1 6.7

Table 7. High Speed Ejection Test Conditions

Test Number	1	2	3	4	5	6	7	8	9	10	11
Test Date	*8/18/93*	*8/25/93*	8/27/93	8/27/93	8/30/93	8/31/93	*9/3/93*	9/9/93	*9/9/93*	9/14/93	9/16/93
Designation	*FL110005*	*SL1400*	FL110005	FL083301	FL105001	SL1050	*FL103012*	FL103012	*FL097516*	FL097516	SL 1295
KEAS	*551*	*729*	545	451	545	532	*508*	510	*483*	483	694
Airspeed (km/hr) (ft/sec)	*1020* *930*	*1350* *1230*	1010 920	836 762	1010 920	985 898	*940* *857*	945 861	*895* *816*	895 816	1285 1171
Event Time (sec)											
Seat 1st Motion	*0.000*	*3.384*	4.424	5.261	7.970	6.196	*INVALID*	3.980	*INVALID*	4.445	5.418
Boom Firing	*0.040*	*3.400*	4.533	5.372	8.082	6.286	*INVALID*	4.082	*INVALID*	4.565	5.508
Seat/Rail Separation	*0.160*	*3.504*	4.560	5.396	8.115	6.320	*INVALID*	4.118	*INVALID*	4.582	5.555
Main Parachute Deployment	*64.768*	*3.680*	72.545	6.480	9.492	7.442	*INVALID*	144.835	*INVALID*	NR	6.980
Seat/Manikin Separation	*64.768*	*5.072*	72.563	6.495	9.523	7.458	*INVALID*	144.840	*INVALID*	NR	6.982

Table 8. Event Timing

Sequence	1	2	3	4	5	6	7	8	9	10	11
Test Date	8/18/93	8/25/93	8/27/93	8/27/93	8/30/93	8/31/93	9/3/93	9/9/93	9/9/93	9/14/93	9/16/93
Designation	FL110005	SL1400	FL110005	FL083301	FL105001	SL1050	FL103012	FL103012	FL097516	FL097516	SL 1295
Manikin	SKIF	SKIF	S-ADAM	L-ADAM	L-ADAM	S-ADAM	SKIF	L-ADAM	SKIF	L-ADAM	S-ADAM
KEAS	551	729	545	451	545	532	508	510	483	483	694
Airspeed (km/hr) (ft/sec)	1020 930	1350 1230	1010 920	836 762	1010 920	985 898	940 857	945 861	895 816	895 816	1285 1171
DRZ/Time											
Accelerometer A DRZ (sec)	16.5 0.133	15.9 3.504	16.5 4.506	13.7 5.362	13.3 8.053	18.3 6.282	INVALID	14.4 4.053	INVALID	14.4 4.529	14.2 5.514
Gz Max (sec)	17.5 0.128	14.6 3.481	16.4 4.534	21.5 5.382	17.3 8.090	21.9 6.296	INVALID	16.7 4.094	INVALID	17.0 4.570	15.5 5.519
Accelerometer B DRZ (sec)	NM	NM	16.3 4.506	13.9 5.363	13.3 8.053	18.3 6.282	NM	14.7 4.052	NM	14.3 4.528	14.4 5.512
Gz Max (sec)	NM	NM	17.2 4.546	21.7 5.382	18.5 8.090	21.6 6.296	NM	16.1 4.094	NM	17.3 4.568	15.2 5.519
Accelerometer C DRZ (sec)	NM	NM	16.6 4.505	13.9 5.345	14.5 8.052	17.8 6.283	NM	14.6 4.052	NM	14.1 4.529	14.4 5.512
Gz Max (sec)	NM	NM	16.2 4.532	16.7 5.380	15.6 8.088	19.5 6.294	NM	14.4 4.094	NM	15.0 4.568	15.7 5.521
Accelerometer D DRZ (sec)	NM	NM	16.3 4.503	14.7 5.341	13.8 8.052	18.1 6.283	NM	15.1 4.054	NM	14.0 4.528	14.5 5.512
Gz Max (sec)	NM	NM	16.5 4.546	22.0 5.382	16.4 8.090	21.9 6.296	NM	16.8 4.094	NM	17.7 4.568	15.8 5.519
Max. Head/Neck											
-Fx (lbs/kg)	NM	NM	4/2	18/8	82/37	0/0	NM	83/38	NM	76/35	108/49
+Fx (lbs/kg)	NM	NM	63/29	87/40	47/21	132/60	NM	63/29	NM	27/12	78/35
Fy (lbs/kg)	NM	NM	63/29	60/27	86/39	37/17	NM	58/26	NM	229/104	46/21
-Fz (lbs/kg)	454/206	751/341	271/123	216/98	259/118	49/22	INVALID	208/95	INVALID	197/90	223/101
+Fz (lbs/kg)	661/300	801/364	20/9	69/31	165/75	82/37	INVALID	1/0.5	INVALID	0/0	161/73
Max. Hand Loads											
Left (lbs/kg)	NM	NM	68/31	1/0.5	38/17	41/19	NM	33/15	NM	58/26	36/16
Right (lbs/kg)	NM	NM	21/10	73/33	147/67	29/13	NM	118/54	NM	79/36	18/8

Table 9. Dynamic Test Results - Seat Initiation to Seat and EjectionSeat Rail Separation

Sequence	1	2	3	4	5	6	7	8	9	10	11
Test Date	8/18/93	8/25/93	8/27/93	8/27/93	8/30/93	8/31/93	9/3/93	9/9/93	9/9/93	9/14/93	9/16/93
Designation	FL110005	SL1400	FL110005	FL083301	FL105001	SL1050	FL103012	FL103012	FL097516	FL097516	SL 1295
Manikin	SKIF	SKIF	S-ADAM	L-ADAM	L-ADAM	S-ADAM	SKIF	L-ADAM	SKIF	L-ADAM	S-ADAM
KEAS	551	729	545	451	545	532	508	510	483	483	694
Airspeed (km/hr)	1020	1350	1010	836	1010	985	940	945	895	895	1285
(ft/sec)	930	1230	920	762	920	898	857	861	816	816	1171
Radical/Time											
Accelerometer A Radical	0.877	1.361	1.061	0.760	0.935	0.853	INVALID	1.073	INVALID	1.036	1.637
(sec)	0.251	3.567	4.644	5.396	8.170	6.336		4.187		4.623	5.611
Gx Max	-19.4	-29.9	-20.0	-13.5	-16.6	-18.0	INVALID	-17.4	INVALID	-16.4	-30.6
(sec)	0.610	3.709	4.990	5.412	8.300	6.390		4.430		4.918	5.567
Gy Max	8.0	9.6	8.0	5.6	6.8	6.8	INVALID	4.5	INVALID	11.3	12.9
(sec)	0.652	3.823	5.028	5.518	8.644	6.608		4.304		5.616	5.885
Gz Max	17.2	27.5	25.3	19.2	21.3	30.2	INVALID	19.9	INVALID	18.7	25.3
(sec)	0.209	3.567	4.566	5.418	8.126	6.338		4.152		4.632	5.613
DRZ Max	15.1	20.3	16.8	12.1	14.6	14.4	INVALID	18.1	INVALID	17.3	25.4
(sec)	0.160	3.629	4.633	5.397	8.190	6.321		4.191		4.663	1.677
Accelerometer B Radical	NM	NM	1.017	0.809	0.982	0.872	NM	1.182	NM	1.016	1.688
(sec)			4.644	5.403	8.178	6.337		4.186		4.594	5.569
Gx Max	NM	NM	-20.0	-11.3	-19.2	-21.9	NM	-18.4	NM	-16.3	-35.3
(sec)			5.018	5.712	8.176	6.334		4.432		4.918	5.565
Gy Max	NM	NM	7.3	5.4	7.6	6.9	NM	3.5	NM	12.7	13.9
(sec)			5.028	5.512	8.664	6.608		4.304		5.616	5.885
Gz Max	NM	NM	25.2	19.8	22.8	29.6	NM	18.9	NM	18.4	24.7
(sec)			4.566	5.418	8.126	6.338		4.152		4.632	5.613
DRZ Max	NM	NM	16.3	12.6	14.5	14.0	NM	18.3	NM	16.5	25.7
(sec)			4.634	5.397	8.189	6.321		4.191		4.662	5.640
Accelerometer C Radical	NM	NM	1.136	0.737	1.068	0.917	NM	1.122	NM	1.030	1.775
(sec)			4.572	5.401	8.178	6.336		4.187		4.623	5.569
Gx Max	NM	NM	-19.6	-12.1	-17.4	-20.4	NM	-18.3	NM	-16.0	-34.6
(sec)			4.988	5.412	8.300	6.334		4.430		4.918	5.565
Gy Max	NM	NM	6.2	4.7	6.3	6.6	NM	3.2	NM	12.1	11.0
(sec)			4.858	5.512	8.644	6.608		4.304		5.616	5.885
Gz Max	NM	NM	22.0	19.1	20.4	28.8	NM	20.2	NM	18.6	26.3
(sec)			4.566	5.418	8.126	6.338		4.152		4.630	5.619
DRZ Max	NM	NM	17.9	12.6	17.0	14.0	NM	19.8	NM	17.1	27.8
(sec)			4.636	5.397	8.191	6.321		4.192		4.664	5.640

Table 10. Dynamic Test Results - Seat and Ejection Seat Rai Separation to Seat and Man(ikin) Separation

Sequence	1	2	3	4	5	6	7	8	9	10	11
Test Date	*8/18/93*	*8/25/93*	8/27/93	8/27/93	8/30/93	8/31/93	*9/3/93*	9/9/93	*9/9/93*	9/14/93	9/16/93
Designation	*FL110005*	*SL1400*	FL110005	FL083301	FL105001	SL1050	*FL103012*	FL103012	*FL097516*	FL097516	SL 1295
Manikin	*SKIF*	*SKIF*	S-ADAM	L-ADAM	L-ADAM	S-ADAM	*SKIF*	L-ADAM	*SKIF*	L-ADAM	S-ADAM
KEAS	*551*	*729*	545	451	545	532	*508*	510	*483*	483	694
Airspeed (km/hr) (ft/sec)	*1020* *930*	*1350* *1230*	1010 920	836 762	1010 920	985 898	*940* *857*	945 861	*895* *816*	895 816	1285 1171
Radical/Time											
Accelerometer D Radical (sec)	*NM*	*NM*	1.071 4.624	0.718 5.402	1.062 8.177	0.884 6.336	*NM*	1.112 4.186	*NM*	0.974 4.647	1.700 5.612
Gx Max (sec)	*NM*	*NM*	-20.5 4.936	-12.7 5.406	-18.5 8.176	-20.9 6.334	*NM*	-19.0 4.432	*NM*	-16.0 5.038	-35.2 5.565
Gy Max (sec)	*NM*	*NM*	7.5 5.028	5.4 5.518	6.7 8.644	6.2 6.608	*NM*	3.9 4.304	*NM*	10.6 5.618	13.7 5.885
Gz Max (sec)	*NM*	*NM*	25.2 4.566	20.0 5.418	19.5 8.142	28.4 6.338	*NM*	20.1 4.152	*NM*	17.9 4.630	25.9 5.613
DRZ Max (sec)	*NM*	*NM*	17.0 4.632	12.7 5.397	16.5 8.195	14.2 6.321	*NM*	19.2 4.192	*NM*	15.9 4.662	26.4 5.640
Seat Rates											
X (rad/sec)	*7.517*	*3.552*	INVALID	0.688	INVALID	INVALID	*INVALID*	5.274	*INVALID*	4.561	INVALID
Y (rad/sec)	*2.950*	*6.688*	INVALID	2.834	INVALID	INVALID	*INVALID*	6.777	*INVALID*	3.922	INVALID
Z(rad/sec)	*2.177*	*2.014*	INVALID	1.227	INVALID	INVALID	*INVALID*	6.319	*INVALID*	3.970	INVALID
Max. Head/Neck											
-Fx (lbs/kg)	*NM*	*NM*	30/14	28/13	52/24	21/10	*NM*	109/50	*NM*	83/38	87/40
+Fx (lbs/kg)	*NM*	*NM*	47/21	98/45	28/13	121/55	*NM*	124/56	*NM*	76/35	198/90
Fy (lbs/kg)	*NM*	*NM*	81/37	41/19	84/38	48/22	*NM*	52/24	*NM*	130/59	140/64
-Fz (lbs/kg)	*360/164*	*466/212*	49/22	110/50	26/12	265/120	*INVALID*	203/92	*INVALID*	198/90	74/34
+Fz (lbs/kg)	*668/304*	*676/307*	276/125	159/72	271/123	161/73	*INVALID*	117/53	*INVALID*	229/104	352/160
Max. Hand Loads											
Left (lbs/kg)	*NM*	*NM*	52/24	21/10	51/23	57/26	*NM*	68/31	*NM*	71/32	112/51
Right (lbs/kg)	*NM*	*NM*	21/10	90/41	88/40	33/15	*NM*	127/58	*NM*	83/38	128/58
Max. Leg Torques											
Left Positive (in*lbs/N*m)	*NM*	*NM*	511/57.7	INVALID	INVALID	133/15.0	*NM*	48/	*NM*	13/1.5	INVALID
Left Negative (in*lbs/N*m)	*NM*	*NM*	11/1.2	INVALID	INVALID	INVALID	*NM*	INVALID	*NM*	270/30.5	1008/114
Right Positive (in*lbs/N*m)	*NM*	*NM*	474/53.6	INVALID	INVALID	6/0.7	*NM*	INVALID	*NM*	INVALID	INVALID
Right Negative (in*lbs/N*m)	*NM*	*NM*	15/1.7	1188/134	1258/142	INVALID	*NM*	482	*NM*	INVALID	1012/114

Table 10. Dynamic Test Results - Seat and Ejection Seat Rail Separation to Seat and Man(ikin) Separation (cont.)

Sequence	1	2	3	4	5	6	7	8	9	10	11
Test Date	*8/18/93*	*8/25/93*	8/27/93	8/27/93	8/30/93	8/31/93	*9/3/93*	9/9/93	*9/9/93*	9/14/93	9/16/93
Designation	*FL110005*	*SL1400*	FL110005	FL083301	FL105001	SL1050	*FL103012*	FL103012	*FL097516*	FL097516	SL 1295
Manikin	*SKIF*	*SKIF*	S-ADAM	L-ADAM	L-ADAM	S-ADAM	*SKIF*	L-ADAM	*SKIF*	L-ADAM	S-ADAM
KEAS	*551*	*729*	545	451	545	532	*508*	510	*483*	483	694
Airspeed (km/hr)	*1020*	*1350*	1010	836	1010	985	*940*	945	*895*	895	1285
(ft/sec)	*930*	*1230*	920	762	920	898	*857*	861	*816*	816	1171
Max. Head/Neck											
-Fx (lbs/kg)	*NM*	*NM*	90/41	280/127	139/63	293/133	*NM*	225/102	*NM*	INVALID	374/170
+Fx (lbs/kg)	*NM*	*NM*	46/21	142/65	205/93	357/162	*NM*	56/25	*NM*	INVALID	260/118
Fy (lbs/kg)	*NM*	*NM*	28/13	69/31	166/75	159/72	*NM*	104/47	*NM*	INVALID	73/33
-Fz (lbs/kg)	*68/31*	*213/97*	105/48	62/28	7/3	472/215	*INVALID*	54/25	*INVALID*	INVALID	34/15
+Fz (lbs/kg)	*71/32*	*948/431*	94/43	1152/524	1418/645	494/225	*INVALID*	89/40	*INVALID*	INVALID	495/225
Max. Parachute Loads											
Left Riser Force (lbs/kg)	*785/357*	*INVALID*	INVALID	INVALID	2385/1084	1556/707	*INVALID*	1033/470	*INVALID*	INVALID	1963/892
Right Riser Force (lbs/kg)	*890/405*	*INVALID*	INVALID	INVALID	1671/760	INVALID	*INVALID*	1044/475	*INVALID*	INVALID	1968/895
Maximum Acceleration (g)	*8.0*	*18.0*	7.0	19.0	19.3	17.5	*INVALID*	8.5	*INVALID*	INVALID	19.8
DRZ	*7.7*	*11.8*	7.2	11.9	17.2	13.1	*INVALID*	7.1	*INVALID*	INVALID	13.3

Table 11. Dynamic Test Results - Post Seat and Man(ikin) Separation

Joint	Hip Flexion		Knee Flexion		Shoulder Flexion/Extension		Hip Abduction/Adduction		Shoulder Medial/Lateral Rotation	
	Minimum (Left/Right)	Maximum (Left/Right)	Minimum (Left/Right)	Maximum (Left/Right)	Minimum (Left/Right)	Maximum (Left/Right)	Minimum (Left/Right)	Maximum (Left/Right)	Minimum (Left/Right)	Maximum (Left/Right)
Manikin Max.	0	95	0	125	-57	178	-30	30	-15	115
FL110005	80.4/77.5	88.9/86.0	92.1/110.9	97.2/**125.2**	2.9/-43.2	7.7/16.0	--/-13.2	**38.6**/-6.2	26.4/20.4	38.0/36.2
FL083301	18.5/23.0	89.3/88.7	**0.0**/16.1	108.9/108.2	1.5/5.5	41.2/17.4	-17.2/-22.5	-1.6/-2.4	29.8/27.7	98.8/76.8
FL105001	12.2/24.3	92.9/90.2	**-0.5**/6.2	111.8/111.7	2.1/4.3	83.8/18.7	-19.5/-30.2	1.0/-3.3	13.4/8.5	83.0/77.9
SL1050	15.7/12.3	86.7/82.0	12.4/22.4	**131.9**/95.8	-17.0/--	55.1/--	-18.6/-33.0	1.4/**32.4**	20.7/31.2	70.6/82.7
FL103012	82.6/76.9	90.2/82.9	106.7/104.7	111.6/--	6.1/12.1	173.7/19.0	-7.1/-21.7	-0.4/-10.7	21.1/16.0	**117.1**/45.5
FL097516	80.2/79.2	91.5/91.1	105.1/103.6	114.7/111.6	3.4/13.4	7.6/16.0	-24.7/-14.4	-4.1/-4.1	-1.7/24.2	12.0/33.8
SL1295	9.5/**4.2**	91.1/91.7	11.1/23.2	116.4/108.7	5.2/2.9	18.2/18.0	-23.4/-34.9	-5.8/-6.1	23.6/11.0	75.9/73.1

Table 12. Manikin Limb Positions

ANALYSIS AND DISCUSSION

Quality and Amount of Data

This test program represented the first use of the ADAM and SKIF manikins during an international joint program. Both manikins met the certification testing requirements and were endorsed for the dynamic environments of the MiG-25 and the High-Speed Test Track. The ADAM performed in conditions that challenged its design. For example, the long set-up times in rain and cold were followed by high-stress testing in an extremely cold (-70 degree F), high-altitude environment, with swampy, wet landing zones followed by long recovery periods before the data could be downloaded to laptop personal computers. The quality and amount of the data collected met the objectives of the program and are believed to be without precedence.

Certification Tests

Aerodynamic Facility

Data Reduction

Data were successfully recorded during the windblast tests using the ADAM data acquisition system (DAS). All data channels were plotted in the raw format and a reduced, filtered format to demonstrate the functionality of each sensor and the DAS. Since these tests occurred in an blow down wind tunnel facility, not all data channels were of primary importance. The primary channels included the head and neck forces measured in the X, Y, and Z directions, hand and arm loads, and all pressure data. Seat accelerations were also of interest because of the unique way the seat was introduced into the airflow.

Equipment Failures

Two equipment failures occurred during the windblast certification tests. During aerodynamic certification test number two at 1290 km/hr, a structural failure occurred in each foot of the SKIF manikin. The failure caused the feet to separate from the manikin. After the feet separated from the manikin, the legs were free to lift completely out of the passive leg restraint system of the K-36 ejection seat. Post-test inspection and analysis revealed that the metal foot attachment in the SKIF was inadequately designed for the dynamic pressures generated. The foot attachment was redesigned. The Russian test team reevaluated the test simulation after this failure and decided that the inertial loads acting on the legs during the catapult phase were not being adequately represented. As the seat enters the windblast in the test facility, the seat and manikin start to slow down and finally stop when they are fully in the airflow. As the seat decelerates to a stop, the inertial loads acting on the legs are in opposite direction to

what is experienced during ejection. To more accurately simulate the inertial loads observed during ejection, the manikins legs were fitted with elastic cords that attached from each foot to the facility floor. These were adjusted to match the total load calculated acting on the leg at seat rail separation, taking into account the inertial loads observed during seat deceleration in the aerodynamic facility. This downward acting load increased as the seat moved up the facility ejection seat rails just as they would when the catapult is firing and increasing its thrust as the seat and crewmember move up the ejection seat rails of the aircraft. The modifications to the manikin and facility were tested successfully at higher dynamic pressures than where the failure occurred.

The other equipment failure was observed in aerodynamic certification test number six. A leg restraint retraction cord, which routes through a snubbing device mounted on the seat, failed. Once the cord failed, the leg was free to move under the influence of the aerodynamic forces generated. Review of previous test records revealed that this seat and leg retraction cord had been used during four previous high-speed windblast tests. Since the leg lines are designed for one time use only, the failure was attributed to fatigue.

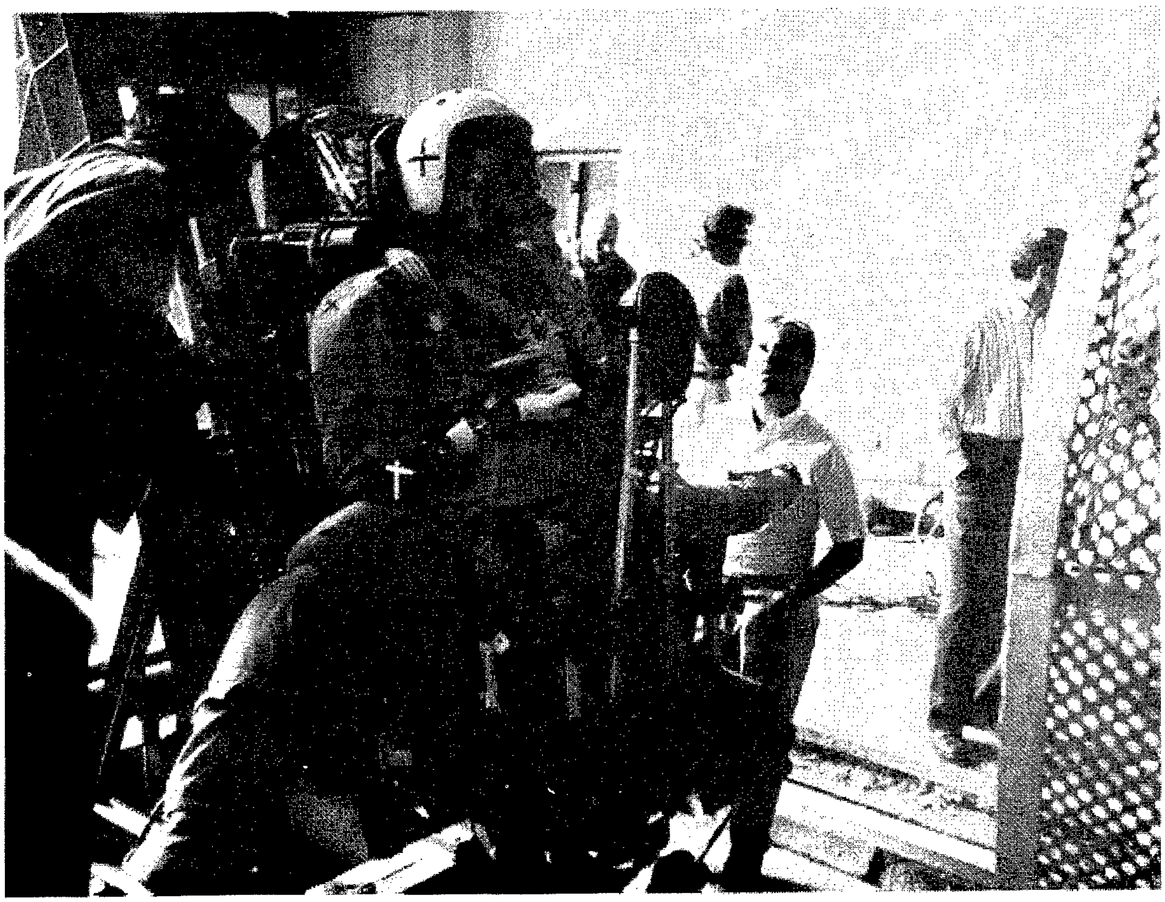


Figure 29 - SKIF Manikin Failure During Test No. 2

Big Vertical Catapult (BVC)

The Russian evaluation of ADAM, SKIF and data acquisition output was favorable and certification was granted to continue the high-speed portion of the FCT program with MiG-25 Flying Laboratory and Rocket Sled track tests. Significant measurements for the catapult tests are shown in Table 7.

The data collected at the BVC indicated that the accelerations and velocities produced by the K-36D would provide sufficient tail clearance for the MiG-25 Flying Laboratory to be used during the inflight tests. The DR_Z showed disparities due to variance of the seat catapult charges. The DR_Z is graphically represented in Figure 30.

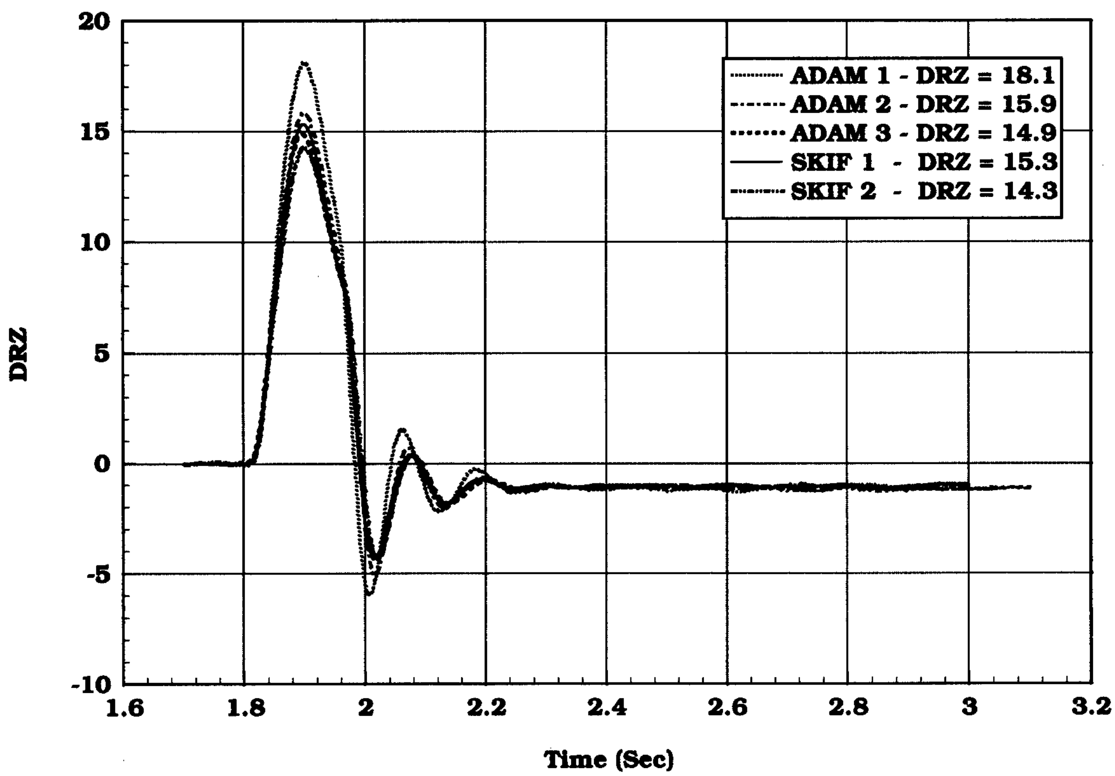


Figure 30 - DR_Z Output for Big Vertical Catapult Tests

High-Speed Ejection Tests

Data Reduction

Raw data from all the tests were plotted immediately after the test data was downloaded to the portable PC. The plots were examined for channel functionality, continuity, and amplitude. A set of sample data can be found in Appendix F. The data were then converted to ASCII format using ADAM software, and were plotted for each channel. These data plots can be found in Appendices G

and H. The high-speed ejection tests were processed for three critical phases of the ejection sequence. These sequences were 1) from ejection initiation to seat separation from the rail, 2) from ejection seat separation from the rail and aircraft/forebody to manikin separation from the seat, and 3) post manikin separation from the seat. Maximums and minimums of data for each phase were determined and recorded in tables 9, 10, and 11. The data were also analyzed using the DRI and Radical to evaluate the acceleration environment during the ejection event.

Seat Stability

The most striking characteristic of the seat flight during this test program was the inherent stability that was observed. As the seat left the test aircraft or forebody, the telescoping booms were completely deployed. Even though these booms are the primary stabilization system of the K-36, some of the other subsystems also contribute to the ejection seat stability. It is known that the windblast deflector affects the overall seat drag and pitching moment and provides some degree of protection to the head and neck and upper body. Lifting retaining the legs with leg restraints, provides protection to the legs and also reduces projected frontal area. The arm paddles also contribute to aerodynamic stability by retaining the limbs so that destabilizing moments are avoided. Figures 31 and 32 show acceleration data versus time for two selected tests. Figure 31 is from the Mach 2.5, 56,000 ft test and figure 32 is from the Mach 2.0, 37,000 ft test. Both graphs contain seat, lumbar, chest and head accelerations.

During the Mach 2.5 ADAM test, the accelerations indicate that the seat trimmed at a non-zero yaw angle. This can be seen in figure 31. The electronic data in general show oscillations that decay with time. Lateral seat acceleration (side-to-side) shows the same oscillation with decaying amplitude. The amplitude of this particular channel settles at 4G's indicating that the seat stabilizes several degrees off axis. This would produce asymmetrical loading accounting for the high side load of the head. Head acceleration at this time was measured to be 12.2 g. The offset can be observed in several of the other acceleration channels. The pressure data collected on the windblast deflector and crewmember visor indicate this misalignment as well. The visor total pressure recorded is greater than the windblast deflector total pressure (12.0 psi vs 8.4 psi) and does not exhibit the oscillatory behavior of the windblast deflector pressure. This would indicate that the windblast deflector was at an angle which did not allow the helmet to be in the wake region.

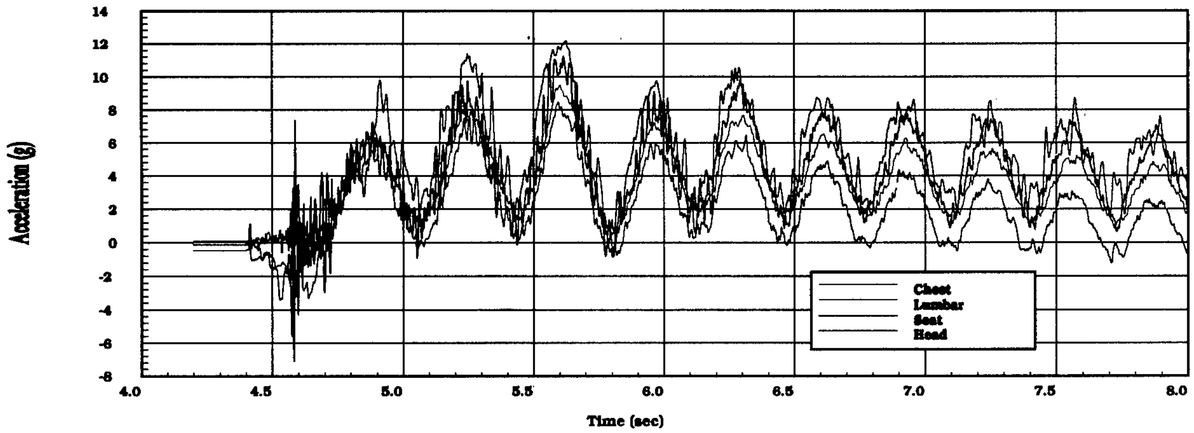


Figure 31 - Accelerations During Mach 2.5 Test

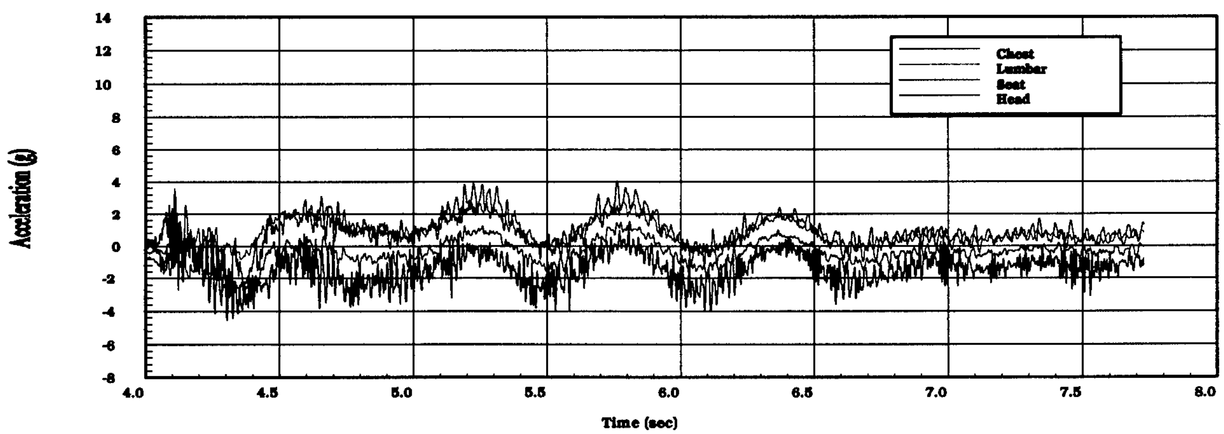


Figure 32 - Accelerations During Mach 2.0 Test

At the higher altitudes, the K-36 ejection seat decelerates more slowly and the effectiveness of the telescoping booms is reduced. The decaying oscillations indicate that the seat is flying to a stable position. The oscillations dampen out within 10 seconds. The data also indicate how well the harness couples the manikin to the seat. The lumbar and chest accelerations are in phase with the seat accelerations. The manikin and seat are moving as a unit. A curious finding was that the manikin head accelerations were also in phase with the seat and manikin torso. The second graph shows the same channels of acceleration but at the Mach 2.0 test at 37,000 ft. The air at this altitude is more dense and the telescoping booms are more effective than at the higher altitude as evidenced by how quickly the oscillations dampen out. The frequency and amplitude of the oscillation is also lower, from 3 Hertz to about 2 Hertz. However in both cases, the seat finds a stable position. At lower altitudes, the seat stabilizes even faster and very small oscillations are observed.

Seat Performance Evaluation Criteria

Table 13 summarizes the evaluation criteria for the ejection test program. An "M" indicates that the test met the criteria whereas an "E" indicates that the test exceeded the criteria, "B" indicates borderline results, and "I" indicates invalid data.

The * in Table 13 indicates that the neck limits were exceeded during parachute opening shock only, and these tests had met neck criteria up to this point of the ejection.

Test	Criteria					
	DR_Z	Radical	Neck X	Grip	Leg Torque	Limb Position
FL110005**SKIF**	M	M	-	-	-	M
SL1400**SKIF**	M	E	-	-	-	M
FL110005	M	B	M	M	B	M
FL083301	M	M	E*	M	E	M
FL105001	M	B	E*	M	E	M
SL1050	E	M	E*	M	M/I	M
FL103012**SKIF**	I	I	I	I	I	I
FL103012	M	E	E*	M	B/I	M
FL097516**SKIF**	I	I	I	I	I	I
FL097516	M	B	E	M	M	M
SL1295	M	E	E	M	E	M

* POS Neck Effect, see neck loads below.

Table 13 - Evaluation Criteria Results

Seat Accelerations

DR(Z)

Table 9 shows the DR_Z values for the tests conducted with ADAM. These values are obtained from the rocket sled and Flying Laboratory tests. This analysis show considerable variability ranging from 13.3 during a 545 KEAS, large ADAM test to 18.3 during a 532 KEAS, small ADAM ejection. The 532 KEAS test is the only test that has a catapult acceleration that results in a DR_Z above the limiting value of 18. The magnitude of the DR_Z for this test is high when compared to the ACES II ejection seat which usually has values near 12.

Radical

Table 11 shows the results of the Radical calculation. The Radical was calculated for each triaxial accelerometer mounted in the K-36D ejection seat. This value exceeds the limiting value in five of the seven tests with ADAM and one of two tests conducted with the Russian SKIF manikin. Of these six tests, two tests were very close to the limiting value of 1, with at least one triaxial accelerometer recording accelerations that produced a Radical calculation of less than 1.

Head and Neck Forces

Tables 10-12 show the head and neck measured loads for three portions of the ejection sequence leading up to seat man separation. A few tests show the criteria to be exceeded.

In the dynamic testing, the oscillation of the seat and its effect on head loading was observed. As the seat oscillated, the pressure on the helmet visor fluctuated (figure 33). These oscillations indicate that high pressures push the head into the headrest while the lower pressures allow the head to move forward due to the inertial forces. This head oscillation is undesirable during escape.

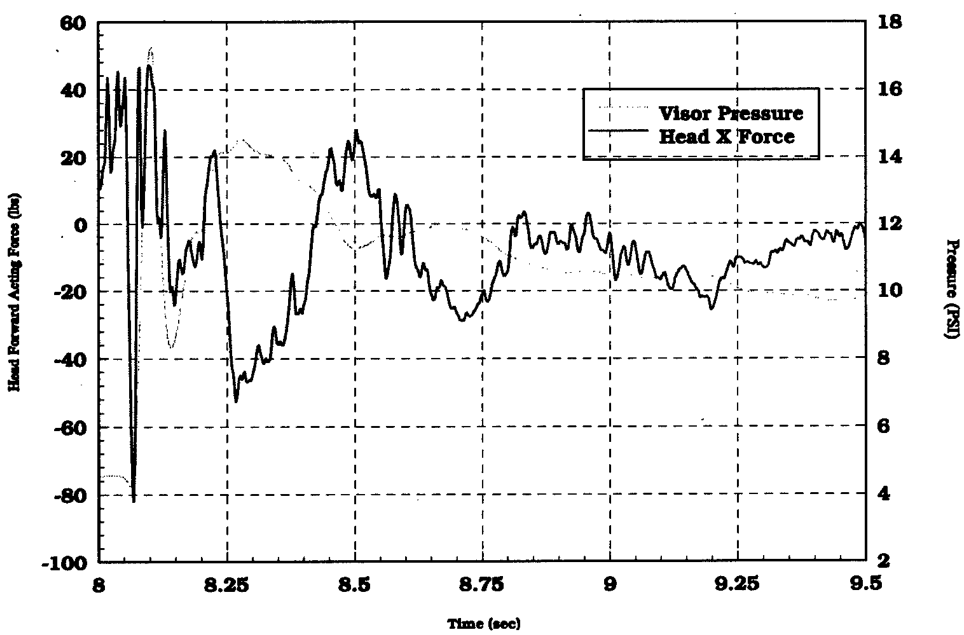


Figure 33 - Head Pressure/Force Interaction

Figure 34 shows the lift and figure 35 shows the forward acting forces on the head and neck for tests FL105001 and SL1050 (both at approximately 550 KEAS). These graphs show the difference between the 5th and 95th %tile manikins behind the windblast deflector. Assuming the 5th %tile manikin to be blanketed by

the wake of the windblast deflector, the positive aerodynamic force should decrease and the inertial load would pull the head out of the headrest. The forward acting force shows this to occur. Also, if the head of the 95th %tile is above the airflow wake, then the aerodynamic force should be larger than the inertial force resulting in a net rearward force on the head. This is also illustrated by the measurement. The lifting force should be the opposite. Protected by the wake and with the majority of the inertial loading acting in the axial direction, the lift load is primarily due to aerodynamic loading. If the 5th %tile is protected more than the 95th %tile the lift force should be smaller. The measured values show that this is the case.

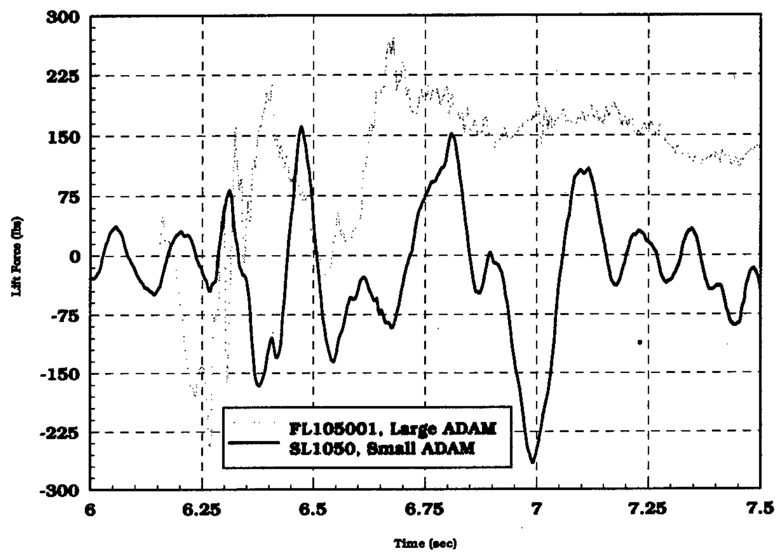


Figure 34 - Neck Lift Forces on Large and Small Manikins

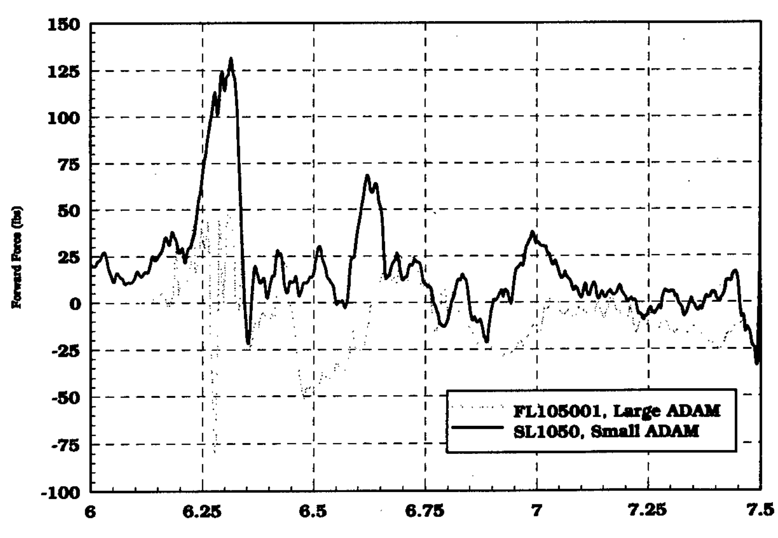


Figure 35 - Neck Forward Forces on Large and Small Manikins

Some very large loads measured at the base of the neck were seen after seat and manikin separation (table 12). These loads occurred on several tests. During the FL105001 test (545 KEAS) with the Large ADAM, the neck tension load was measured to be 1418 lbs. Even at the lowest test speed in this series, FL083301 (450 KEAS), the neck tension load was measured to be 1152 lbs. During the sled test with the small ADAM at 532 KEAS, the neck forward, compression, and tension loads were 357, 472, and 494 lbs respectively, all of which exceeded the safe neck criteria. However, during test FL110005 (545 KEAS) with the small ADAM, none of the neck loads exceeded 105 lbs during this phase of the ejection. The photo optical coverage of these tests is not of sufficient quality to allow additional analysis. Neck loads this large are beyond all known criteria and would certainly cause injury.

When confronted with the neck load data, Zvezda personnel stated that no injuries of the head and neck are recorded in the ejection history of the K-36D. Several explanations were offered in defense of the seat performance. These included test related seat and manikin separation difficulties, possible entanglement with the seat recovery system and inadequate representation of the human head and neck response when using ADAM. These items are discussed in more detail below.

The crewmember and ejection seat separation method used for the K-36D ejection seat is unlike that of the ACES II ejection seat. The recovery parachute deployment and the crewmember release from the restraint system is performed simultaneously. When this occurs, the pyrotechnic charge which deploys the recovery parachute applies a reaction force to the seat, forcing the seat away from the crewmember. The drag on the parachute and risers act to align the crewmember for parachute first full inflation. In this program, the parachute headbox deployment started the seat movement but the instrumentation umbilicals appeared to inhibit the seat and manikin separation. The force required to separate the instrumentation connectors between the seat and manikin may have been high enough to slow manikin and seat separation. If the seat did not move away from the manikin, the seat inertia and mass would be added to that of the manikin, which could result in the manikin not being properly positioned as the parachute began its inflation. In addition, as long as the crewmember is coupled with the seat, the combination is in an aerodynamically stable position which is not suitable for correct alignment. As a result, the first full inflation of the parachute could cause large radial motion and overshoot in the manikin as it realigned with the parachute resulting in a whipping motion of the head.

The potential for the seat recovery parachute to entangle with the manikin during seat and manikin separation was also explained. When the seat was slow to separate from the manikin, the recovery parachute bag would begin to deploy in the airspace between the manikin and seat. Also, two of the attachment points for the recovery parachute were located on the seat near the shoulders of the

manikin. This situation provided the opportunity of potential interference but could not be verified because of the lack of film data.

A third explanation for the high neck loads during parachute opening is the dynamic characteristics of the ADAM Hybrid III neck. The neck is a rubber structure which flexes to simulate human head motion as loads are applied. With the neck in a non-neutral position, potential energy is stored within. If the force is suddenly removed from the neck, it will react much like a spring. This potential/kinetic energy transfer can slingshot the head past the neck neutral point and result in the measurement of a large force. Also, the neck has been shown in the laboratory to be a poor representation of the human neck in fore and aft direction during dynamic events.

Other methods can and are used to make general observations about the severity of parachute opening. Traditionally, riser loads, manikin accelerations and models are used to evaluate parachute opening to compensate for the limited criteria. All of these quantities were investigated and were found to be within the limits that are considered to be safe. The issue is being studied further. Plans are being made for future programs to test the separation of the manikin and seat to insure clean separation and proper alignment prior to parachute opening.

Grip Strength

Studies of two handed retention on various handle configurations were done by Garret, *et al*, to determine the maximum force which could be manually resisted by a subject's grasp on four distinct handle configurations. Garret determined that "...the T-bar and Twin handles (Twin Class) are quite comparable and both superior to the Gemini loop and D-ring handles (Ring Class), which are also quite comparable." The Russian K-36DM ejection handle is most similar to what Garret refers to as the T-bar, whereas the ACES II and Martin-Baker handles are most similar to Gemini loop. Horner and Hawker later followed up with a study which determined the probability of letting go for the two classes of handles. Figure 36 shows the results of this study. The twin class handles, such as the K-36DM ejection seat employs, results in the ability for one to retain approximately 70 pounds more than the ring class handles. The K-36DM seat handle also releases during seat/man separation, unlike the ACES II and NACES, which remain with the seat and the pilot's hands during seat/man separation.

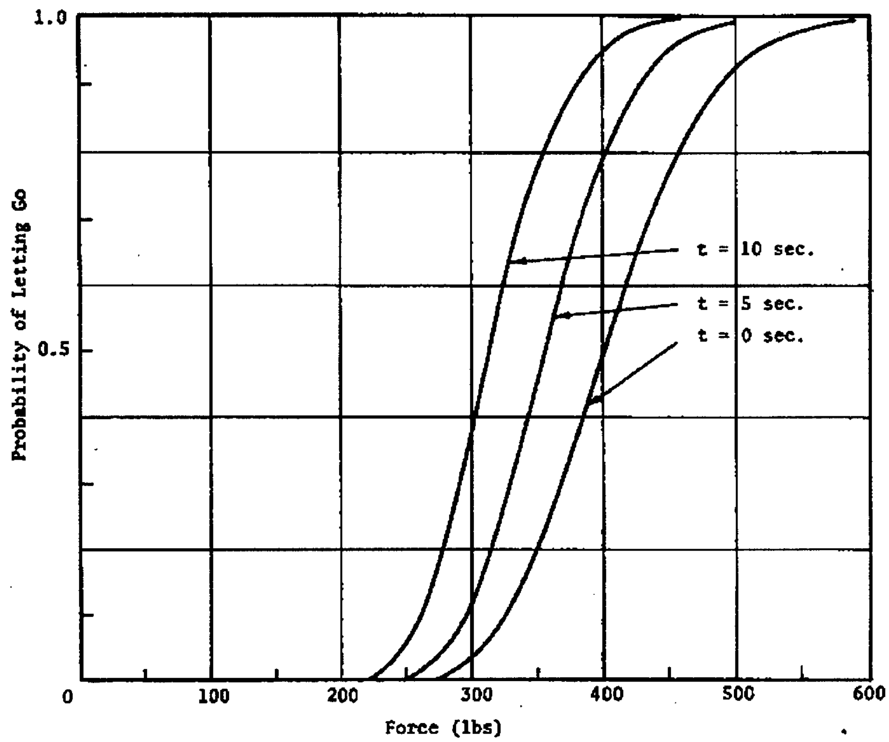


Figure 36 - Probability of Letting Go as a Function of Time for the Twin Class Grips

The hand loads measured during this test program were very low. The highest total load measured was 237 pounds which is below the 1% curve for grip retention for 95% of the adult male population when using twin grips. The arm restraint paddles are effective in reacting the total arm loads and reducing the load required for the crewmember to maintain his grip. Without the paddles, the ability for the crewmember to hold on to the ejection handles would depend solely on the crewmember's grip strength.

Lower Leg Torque

Several of the dynamic tests exceeded lower leg torque criteria. In all the cases where the criteria was exceeded, the legs forcibly rotated into an outward position. Examination of the high-speed motion picture film is consistent with the electronic data. In several cases, the lower leg torques caused the load cells to saturate which indicates torques greater than 1000 in • lbs, which is 45% higher than the high-end limit determined by Grood. Windblast protection for the lower legs should prevent this outward rotation. Current US programs are demonstrating lower leg panels which would prevent this rotation while restraining the leg against the seat.

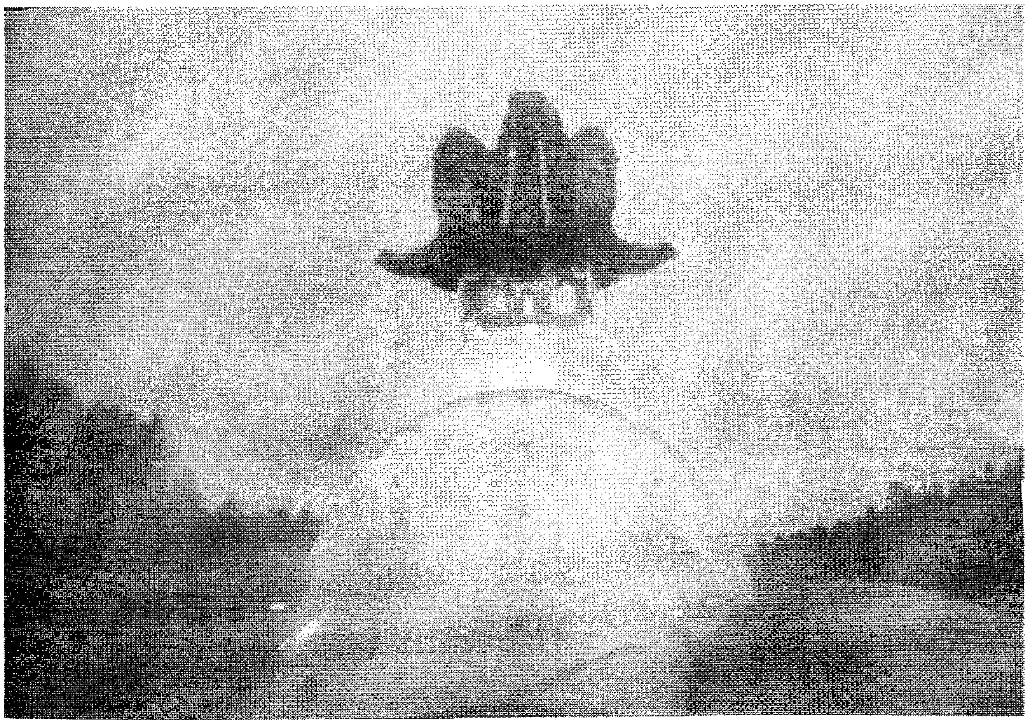


Figure 37 - Lower Leg Torque Illustration

Evaluation of Limb Rotations

Table 13 summarizes the maximum and minimum positions of the limb motions on all of the ADAM tests. The bolded values indicate that the particular limb was at its extreme motion. Several tests resulted in a limb segment being at its maximum position which indicates that there is a potential for hyperextension of that limb.

Parachute Opening Shock

Manikin chest accelerations were examined to determine if the acceleration induced by parachute opening shock exceed 25 G. None of the test data exceeded this criteria. DR_Z analysis was performed during the time of parachute opening shock using the lumbar Z acceleration. None of the test data exceeded the criteria of a DR_Z of 18.

Thermal Analysis

Table 15 shows temperatures measured during the Mach 2 and 2.5 tests with ADAM. The highest temperatures were measured during the Mach 2.5, 56000 ft test. The measurements were made with temperature sensitive paint applied by Russian technicians. As various temperature levels were reached, the paint that was sensitive to that particular temperature would melt away. The remaining bands of paint gave visual evidence of the temperatures not reached. In

all cases, the temperatures were below calculated stagnation temperatures for the conditions of the test. None were high enough to cause injury.

M=	2.0	2.5
Visor	113 °F	147 °F
Helmet	127 °F	181 °F
Chest	127 °F	189 °F
Abdomen	127 °F	171 °F
Shoulder	136 °F	187 °F
Hand	147 °F	192 °F
Forearm	136 °F	183 °F
Knee	136 °F	189 °F
Toe	136 °F	196 °F

Table 14 - Thermal Data

Comparison with Western Seats

Seat Stability

Examination of the high speed motion picture film for each of the tests indicates that the seat was very stable and made an extremely smooth transition from the aircraft rails to free-flight. Films of the high altitude tests (46,000 and 56,000 ft) showed a damping pitch oscillation as the seat left the rails.

Trajectories

Trajectories will be a point of controversy where the K-36 is concerned. In this test program, seven tests were conducted from the flying laboratory and trajectory data could not be collected. It was, however, provided by Zvezda from the three sled tests. In general terms, the maximum altitudes attained for the 532 KEAS (small ADAM), 694 KEAS (small ADAM) and 729 KEAS (SKIF) were 120 feet, 110 feet and 35 feet respectively. In these tests, the seat traveled 1,670 feet, 1,770 feet, and 1,800 feet downtrack, respectively. In comparison, a typical ACES II ejection during a rocket sled test at 600 KEAS would produce a trajectory of approximately 100 feet in altitude and 1,500 feet downtrack.

Computer simulations illustrate optimal trajectories for an ejection seat to be one with a large vertical altitude gain while having a small horizontal downrange displacement to counter high sink rates of disabled or damaged aircraft. Some ejection seat altitude improvement can be obtained by increasing the total impulse of the sustainer rocket, providing the ejection seat is positioned correctly. Minimizing the horizontal downrange displacement can be accomplished with rapid, tolerable crewmember deceleration, quick separation from the seat, and quick recovery parachute operation. However, it the crewmember is decelerated too

rapidly, serious injuries may result. Also, if the recovery parachute is deployed at too high of a velocity, the parachute can fail and result in a high sink rate of the crewmember.

For low-altitude ejections, especially when the aircraft has a large vertical velocity, minimizing the time to full recovery parachute inflation is most critical. During high-speed ejections, it is imperative that the seat first be stabilized and decelerated to a velocity where the recovery parachute can be safely deployed. To optimize performance for ejection over the various flight regimes, modern ejection seats have a sequencer which receives velocity and altitude information and determines the timing of pertinent events. The timing of these events is usually referred to as mode of operation. For example, the ACES II ejection seat has three modes of operation: mode 1 is for low speed, low altitude, where the sequencer immediately initiates deployment of the recovery parachute. Mode 2 is for high-speed, lower-altitude conditions, during which the sequencer first deploys a stabilization drogue parachute which decelerates the seat, then the recovery parachute is deployed. Mode 3 is for high-altitude conditions, during which the drogue parachute is deployed and remains deployed until the seat reaches a lower altitude. Once this altitude is reached, the sequencer instructs the seat to sever the drogue parachute and deploy the recovery parachute. Newer ACES II ejection seats have continuous timings based on the altitude and airspeed at the time of the ejection. The K-36 determines similar timings (Table 1), as discussed in the Test Item section of this report on page 15.

The minimum time from ejection seat and aircraft rail separation to deployment of the recovery parachute for the K-36 is 650 msec versus 2 msec for the ACES II. As the ejection velocity increases to mode 2 for the ACES II seat, the delay time becomes approximately 1 second. The K-36 has a variable time delay as a function of airspeed from 0.650 seconds at 370 KEAS to 3.5 seconds at 700 KEAS. However, at the speeds tested during this test program, the times from seat initiation to parachute full inflation appeared to be similar to the ACES II. This can be due to the differences in the methods of deploying the recovery parachutes. The ACES II uses a reefing system to aid in deploying the C-9 recovery parachute during high-speed deployment. The reefing system also slows the deployment of the parachute at lower speeds. The K-36 uses a slotted parachute for recovery. During high-speed deployments, eight symmetrically placed slots are forced open and air is allowed to flow through them, reducing the load on the crewmember and the parachute. When the K-36 recovery parachute is deployed at lower airspeeds, the lower dynamic pressures do not cause all the slots to fully open and the recovery parachute acts similar to an unslotted, unreefed parachute. Therefore, the slotted K-36 recovery parachute can possibly inflate and become effective in less time than the reefed ACES II recovery parachute.

The lower Gx accelerations experienced with the K-36 and the longer time before the recovery parachute deploys results in a greater downrange

displacement than Western seats. However, the K-36 vertical displacement is much greater than Western seats. During the SL1050 (532 KEAS) ejection test, the crewmember ascended to a height of 130 feet and traveled 1410 feet downrange, and for the SL1295 (694 KEAS) the height was 62 feet with a downrange distance of 1,900 feet. A 600 KEAS test conducted with the ACES II seat resulted in an altitude of 90 feet and a downrange distance of 1,500 feet. Other data indicate that for a 350 KEAS test, the K-36 had a downrange displacement of almost 1,000 feet, the ACES II had a downrange displacement of about 950 feet and the NACES about 850 feet, however, the maximum altitude of the K-36 was 120 feet versus 100 feet for the ACES II and only 80 for NACES. These altitudes are also a critical factor in recovery from ground level and sink rates. The propulsion system essentially provides a velocity change in the Z direction which is responsible for the differences in the altitudes. So while the K-36 may travel further down range than either the ACES II or NACES, the K-36 produces substantially more altitude gain then either of the other seats. However, when large sink rates become more prevalent, the improvement of the larger vertical velocity change of the K-36 is overshadowed by the slower sequencing of the recovery parachute. For example, if the K-36 ejected from an aircraft traveling at 532 KEAS (similar to SL1050) with only a -10° flight path angle, the resulting vertical velocity would be approximately 160 feet/second. At this velocity the K-36 has a 2 second recovery parachute delay time whereas the ACES II has approximately 1 second delay. The K-36 therefore has the potential to lose 160 feet of altitude over the ACES II in that one second difference, *assuming* the recovery parachutes become effective at the same time after initiation. Even if the 40 foot altitude difference is taken into account, this still leaves a 120 foot loss of altitude of the K-36 over the ACES II.

It is clear that additional trajectory analysis is required to fully assess the effects of sink rate, ejection velocity, and parachute opening times. The K-36 slotted recovery parachute needs to be tested to determine if this design can compensate for the seat's longer delay times. The sequencing of the K-36 also needs to be studied to optimize performance.

Radical

Figure 38 compares the K-36 test Radicals with previously calculated values for the ACES II, NACES, and S4S. The S4S Radical values were calculated using manikin accelerations. All other values shown were calculated using seat accelerations.

The differences observed between the western style seats and the K-36D is striking. The K-36D ejection seat outperforms Western style ejection seats at the speeds investigated. Most of the difference in the Radical values is due to the stability of the K-36D and the increased weight of the seat and manikin combination. With a stabilized seat, the direction of the deceleration is controlled to

align primarily within the most tolerable axes for the crewmember. The aerodynamic coefficient of drag (C_d) of the K-36 with stabilizing booms deployed, when multiplied by the projected frontal area (S), is reported to be 7.9 ft^2 for a 50th percentile manikin. Western seats such as those represented in Figure 38 have a C_dS of 14.4 ft^2 for a 95th percentile manikin when the drogue parachute is deployed. Scaled to a 50th percentile crewmember the C_dS could be as low as 13.5 ft^2. *For equivalent ejected weights,* the difference in C_dS for a 50th percentile crewmember would translate to equivalent deceleration levels when the K-36 is traveling at 730 KEAS and an ACES II is traveling at 540 KEAS.

If the weight of the ejection seat is considered, *the acceleration environment* at high speeds with the K-36 is improved further still. The K-36 ejected weight is approximately 504 lbs to 423 for the ACES II. If the C_dS of the previous paragraph is used along with these ejected weights, then equivalent acceleration environments would be found when the K-36 is traveling at 730 KEAS and the ACES II is traveling at 495 KEAS. The Radical calculation supports this calculation.

While both of these characteristics are desirable during high-speed ejection when there is sufficient time to slow the ejection seat down and deploy the main parachute, there are negative features during low-altitude flight. It appears that additional altitude is required for parachute deployment.

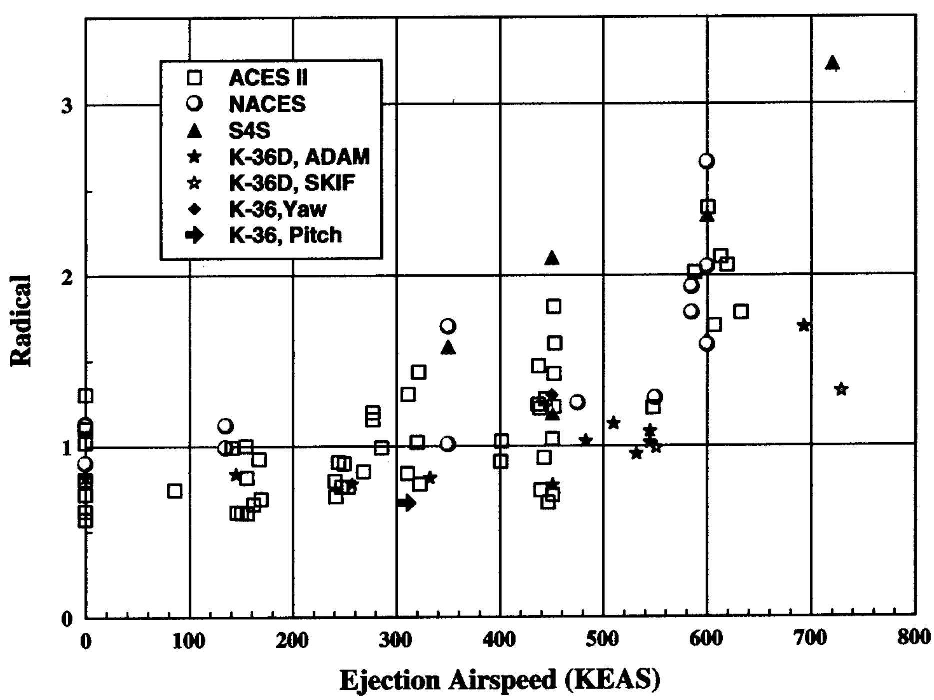


Figure 38 - K-36D, ACES II, NACES, and S4S Sled Test Radicals

For straight and level ejections at high-speed and moderate altitudes, the K-36D comes close to meeting the requirements of what's expected of the newer ejection seat technologies being developed. However, ejections from adverse initial aircraft attitudes have not been addressed by the K-36D FCT and the next generation of Western ejection seats will help the crewmember in these situations. It is speculated that the simpler technologies of the K-36D may be able to meet these conditions with small modifications. Additional testing is required to evaluate the stabilization technologies of the K-36D when subjected to these conditions.

SUMMARY

Test Program

The Air Force and Navy test program evaluated the Russians' claim of high-speed performance to speeds up to 729 KEAS using instrumented US manikins and injury assessment methods. The testing effort was conducted in Russia using their test facilities, which included an ejection tower, a high-speed, blow-down wind tunnel, a rocket-propelled sled, and a uniquely modified MiG-25. After the completion of wind tunnel and ejection tower testing, 11 successive, successful ejections were performed at speeds up to 729 KEAS. These tests included ejections from the MiG-25 at Mach numbers up to 2.5 at an altitude of 56,000 ft.

Test Results

The test results demonstrated that the K-36 ejection seat provides superior high-speed stability, windblast protection, and reduced occupant accelerations at airspeeds beyond those formerly thought to be feasible with US technology. The K-36 ejection seat accelerations at 729 KEAS were similar to those measured on the ACES II and NACES ejection seats at speeds of about 450 KEAS. This represents a 300 KEAS improvement in current escape system performance as far as the acceleration environment is concerned. What makes this remarkable is the fact that the force acting on the crewmember and ejection seat combination is increasing with the velocity squared, so that at 729 KEAS, the total force acting on the combination is almost 3 times the force acting on the seat and crewmember combination at roughly sixty % of the speed (450 KEAS). The combination of the windblast deflector, the vented helmet, the arm retention paddles and the leg lifters acting in combination with the restraint systems of the K-36 provided reduced occupant loads throughout the free-flight portion of the escape sequence.

Implication of Test Results

There are many important accomplishments associated with this program. First of all, the US test team has demonstrated that American engineers and scientists can work very successfully with their Russian counterparts and a good working relationship has been established. The US team also learned that an ejection system composed of parts that resemble those designed and built by the US may not yield the same performance when the system configuration is changed. The total integrated seat,

occupant, and personal equipment design appears to yield the key to the success of the K-36D system performance.

The factors that are the underpinnings of the K-36D system design that are learned by close association with Zvezda are: First, the team that has developed the K-36D has a solid understanding of the scientific principles behind the operation of the system. As a result, anomalies that are observed in test data are quickly understood and remedial action is taken with a high probability of success. Second, more extensive experimental test and evaluation appears to have been accomplished during the system development than would be the case in the development of similar systems in the US. Furthermore, additional test and evaluation is conducted to continuously improve the system after its operational deployment. And third, the crew systems developed by Zvezda were under the direction of a single technical authority.

Future Considerations

Adverse Attitude Testing

Additional tests are now planned to evaluate the K-36 ejection seat performance under adverse attitude and roll rate conditions that are know to be beyond the capabilities of ejection seats currently deployed in US aircraft. Low-speed tests are also planned to gather the data necessary to assess the seat performance in areas where Western style seats are considered good performers. These tests will be performed by USAF, Navy, and Russian engineers at Holloman Air Force Base in FY 96.

Testing Concerns

High head and neck loads were observed in several tests conducted in the high-speed program during the parachute opening phase of the ejection. Inadequate data were obtained to answer the question of whether or not the excessive loads were related to the test configuration and setup. Certainly, additional tests are required to address this problem and insure correct crewmember and parachute riser alignment during parachute opening for successful ejection.

Measured lower leg torques were also very high during the test program. Western escape systems with lower leg restraints consisting of garters and straps that are somewhat similar to the leg retention system of the K-36D are known to correctly position the legs during ejection but allow outward twisting of the lower legs to the extent that knee derangement is often observed. Lower leg garters and retention straps only comprise part of

the total solution required. As a minimum, panels should be in place on the ejection seat during ejection to prevent the rotation of the foot and lower leg.

Historically, heavier ejection seat systems tend to have more stable trajectories but also have poor low-speed performance records associated with them. The time required to develop a fully inflated parachute is longer for the K-36D than the ACES II. Although the K-36D has a higher impulse rocket motor than the ACES II, it is speculated to be insufficient to overcome the high sink rates encountered in some ejection scenarios. The low-speed problem will be addressed in the next phase of the test program.

Also, little information is available concerning the recovery parachute of the K-36. Although the descent rate is advertised to be 18 ft/sec, descent rates higher than this were observed in the test films. Additional data for the assessment of the descent rates of the recovery parachute when compared to the parachutes used in the US is needed.

Recommendations

The K-36 FCT has demonstrated the *potential* of increasing the range of emergency conditions where aircrew may safely escape from high-speed aircraft. The program has demonstrated a successful business method using a US contractor, Rockwell International, and a Russian joint venture legal agreement between Zvezda and a company based in the United Kingdom, IBP Aircraft, Limited. If additional testing at low-speed and adverse attitudes prove favorable, the K-36 ejection seat could be built for the US under a license agreement with Zvezda. The K-36 technology could be also be used in a design partnership between Zvezda (now a privatized research, development, and production enterprise) and a US company to produce a new ejection seat using the best of Russian and US technologies for future US military aircraft as well as the international market.

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Appendix A

US Sensors

Table A-1 lists the manufacturers and model numbers for each of the electronic sensors used in this test program.

Measured Parameter	Manufacturer	Model Number
Seat Acceleration	Entran	EGV3-F-250
Seat Rates	ATA	ARS-01
Head & Lumbar Acceleration	Entran	EGA-125F-100D
Chest Acceleration	ICSensors	3021-100-S
Head & Chest Angular Acceleration	Endevco	7302B
Neck Forces & Moments	Denton	1716A
Lumbar Forces & Moments	Denton	1914A
Parachute Riser Force	Russian	-
Leg Force (Torque)	HiTEC	HLR-3000
Pressure - Gage	Kulite	LE-125-25SG
Pressure - Absolute	Kulite	LQ-80-50A

Table A-1. Electronic Sensors

Appendix B

ADAM Data Channels

Table B-1 lists the ADAM Data Channels recorded and the engineering units for each channel during the test program.

Channel	Channel Description	Units
1	Lt Hip Flexion	degrees
2	Lt Hip Abd/Adduction	degrees
3	Lt Knee Flexion	degrees
4	Rt Hip Flexion	degrees
5	Rt Hip Abd/Adduction	degrees
6	Rt Knee Flexion	degrees
7	Static Pressure Internal	psi
8	ADAS Internal Temperature.	degrees F
9	Lt Shoulder Flexion	degrees
10	Lt Shoulder Medial/Lateral	degrees
11	Rt Shoulder Flexion	degrees
12	Rt Shoulder Medial/Lateral	degrees
13	Lt Parachute Riser LD #1	lbs
14	Rt Parachute Riser LD #2	lbs
15	Lt Arm Lift	lbs
16	Rt Arm Lift	lbs
17	Lumbar Force X	lbs
18	Lumbar Force Y	lbs
19	Lumbar Force Z	lbs
20	Lumbar Moment X	in-lbs
21	Lumbar Moment Y	in-lbs
22	Lumbar Moment Z	in-lbs
23	Total Pressure Windblast Deflector	psi
24	Static Pressure Windblast Deflector	psi
25	Chest Acceleration X	G
26	Chest Acceleration Y	G
27	Chest Acceleration Z	G
28	Head Acceleration X	G
29	Head Acceleration Y	G
30	Head Acceleration Z	G
31	Chest Angular Acceleration Y	rad/sec^2
32	Head Angular Acceleration Y	rad/sec^2

Table B-1. ADAM Data Channels

Channel	Channel Description	Units
33	Lumbar Acceleration X	G
34	Lumbar Acceleration Y	G
35	Lumbar Acceleration Z	G
36	Lt Leg Torque POS	lbs
37	Lt Leg Torque NEG	lbs
38	Rt Leg Torque POS	lbs
39	Rt Leg Torque NEG	lbs
40	Rail Velocity	volts
41	Head/Neck Force X	lbs
42	Head/Neck Force Y	lbs
43	Head/Neck Force Z	lbs
44	Head/Neck Moment X	in-lbs
45	Head/Neck Moment Y	in-lbs
46	Head/Neck Moment Z	in-lbs
47	Total Pressure Chest ADAM	psi
48	Total Pressure Visor	psi
49	Seat Acceleration Block 1.X	G
50	Seat Acceleration Block 1.Y	G
51	Seat Acceleration Block 1.Z	G
52	Seat Acceleration Block 2.X	G
53	Seat Acceleration Block 2.Y	G
54	Seat Acceleration Block 2.Z	G
55	Seat Acceleration Block 3.X	G
56	Seat Acceleration Block 3.Y	G
57	Seat Acceleration Block 3.Z	G
58	Seat Acceleration Block 4.X	G
59	Seat Acceleration Block 4.Y	G
60	Seat Acceleration Block 4.Z	G
61	Seat Angular Rate X	rad/sec
62	Seat Angular Rate Y	rad/sec
63	Seat Angular Rate Z	rad/sec
64	Signal	Volts

Table B-1. ADAM Data Channels (cont.)

Appendix C

SKIF Data Channels

Table C-1 lists the SKIF Data Channels recorded and the engineering units for each channel during the test program.

NAMES	CHANNEL	UNIT
a01	Seat Angular Rate About X	rad/sec
a02	Seat Angular Rate About Y	rad/sec
a03	Seat Angular Rate About Z	rad/sec
a04	Manikin Pelvic Acceleration X	G
a05	Manikin Pelvic Acceleration Y	G
a06	Manikin Pelvic Acceleration Z	G
a08	Manikin Head Force Z	kg
a09	Left Parachute Force	kg
a10	Right Parachute Force	kg
b01	Manikin Head Acceleration X	G
b02	Manikin Head Acceleration Y	G
b03	Manikin Head Acceleration Z	G
b04	Seat Acceleration X	G
b05	Seat Acceleration Y	G
b06	Seat Acceleration Z	G
b07	Seat Displacement	v

Table C-1. SKIF Data Channels

Appendix D

Seat Inertial Properties

Table D-1 lists the seat mass and inertial properties for each test.

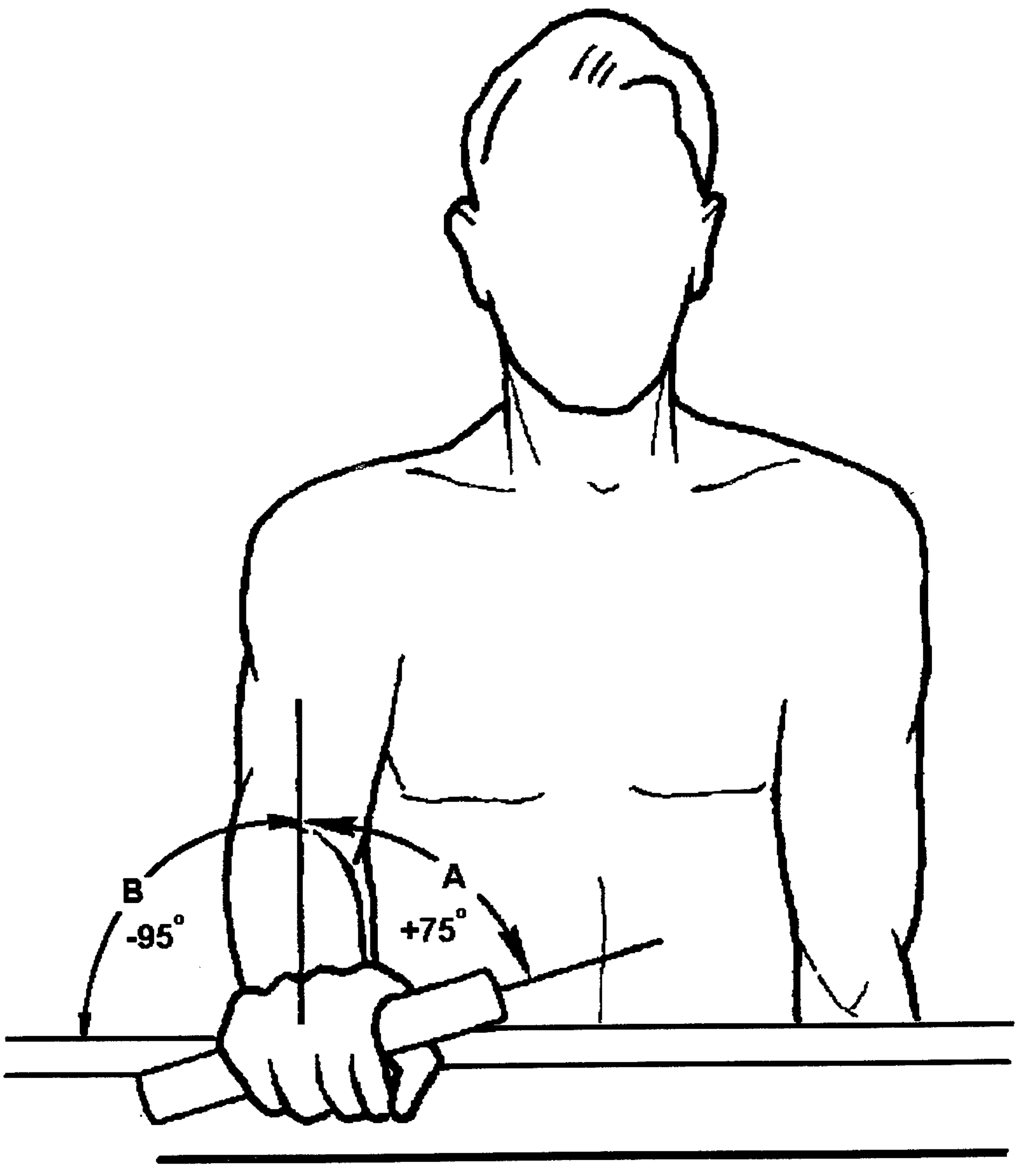
Test #	Designation	Mass (lb)	CGx (ft)	CGz (ft)	Ix (Slug* ft^2)	Iy (Slug* ft^2)	Iz (Slug* ft^2)	Ixy (Slug* ft^2)	Iyz (Slug* ft^2)	Izx (Slug* ft^2)
1	FL110005	462.154	0.784	1.168	24.660	32.071	15.400	0.000	0.000	-5.675
2	SL1400	463.540	0.801	1.168	24.369	33.472	14.851	0.000	0.000	-6.038
3	FL110005	411.070	0.705	1.066	20.699	27.468	13.529	0.000	0.000	-5.325
4	FL083301	487.410	0.801	1.171	25.453	33.399	16.297	0.000	0.000	-6.063
5	FL105001	488.290	0.801	1.171	25.453	32.818	15.716	0.000	0.000	-6.035
6	SL1050	412.038	0.705	1.066	20.699	27.468	13.529	0.000	0.000	-5.325
7	FL103012	461.560	0.774	1.168	24.658	32.051	15.382	0.000	0.000	-5.645
8	FL103012	492.690	0.807	1.171	25.309	32.975	15.764	0.000	0.000	-6.085
9	FL097516	463.958	0.787	1.184	24.366	33.446	14.828	0.000	0.000	-6.022
10	FL097516	494.450	0.823	1.171	25.597	33.221	16.047	0.000	0.000	-6.181
11	SL1295	490.380	0.804	1.175	26.016	31.249	14.814	0.000	0.000	-6.191

Table D-1. Seat Inertial Properties

Appendix E

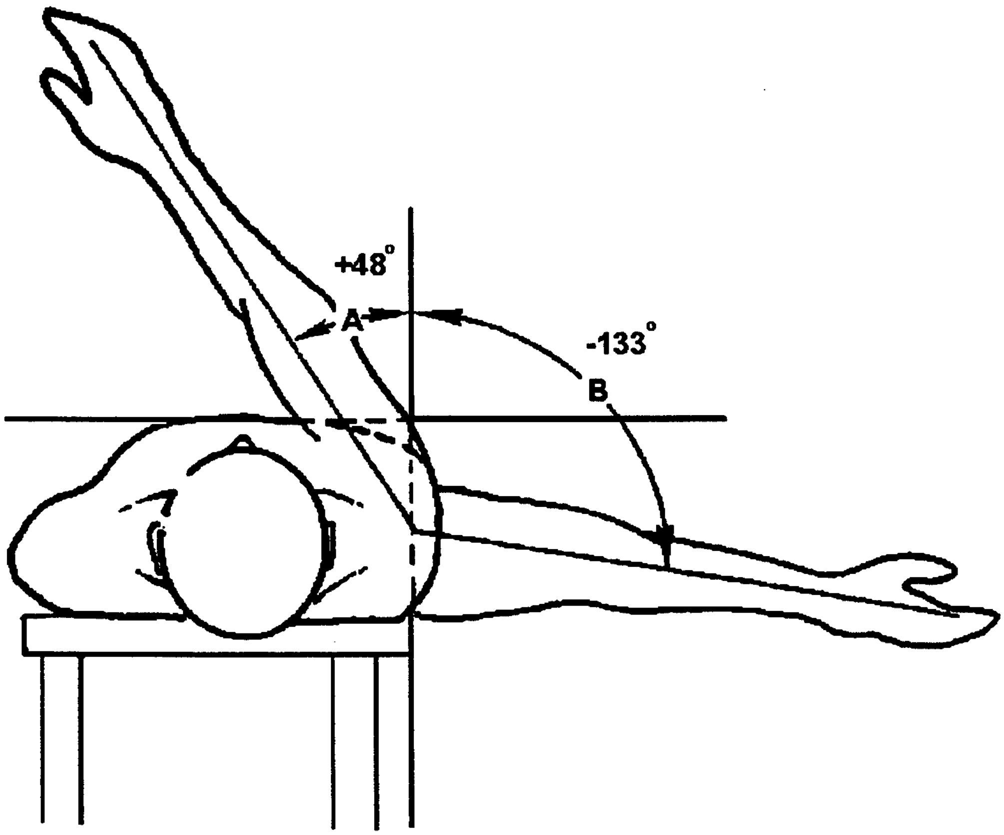
Limb Motion Description

Figures E-1 through E-6 illustrate the ADAM limb positions and limits.



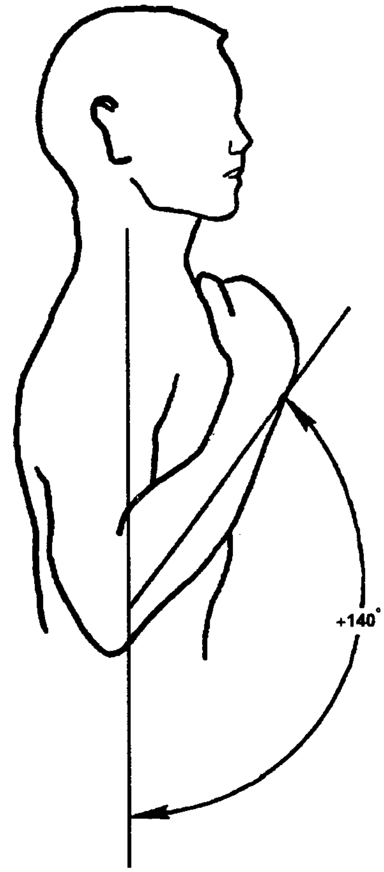
Forearm Pronation/Supination
(A - Pronation; B - Supination)

Figure E-1. Forearm Pronation/Supination

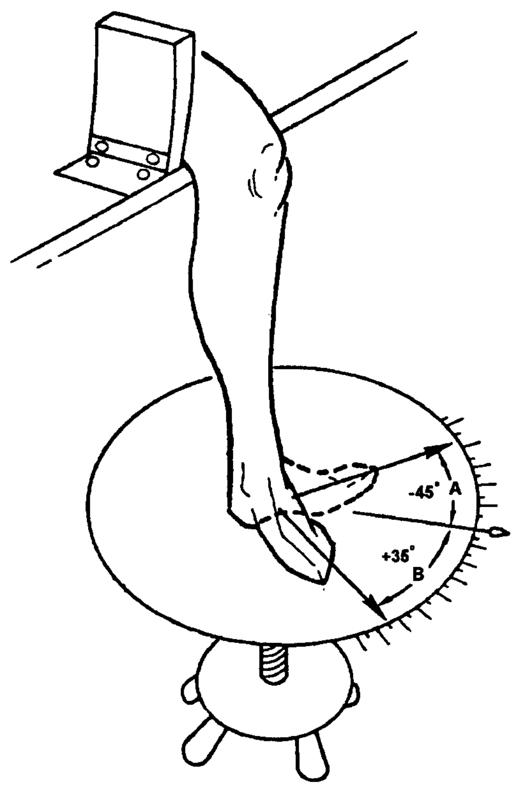


Shoulder Adduction/Abduction
(A - Adduction; B - Abduction)

Figure E-2. Shoulder Adduction/Abduction

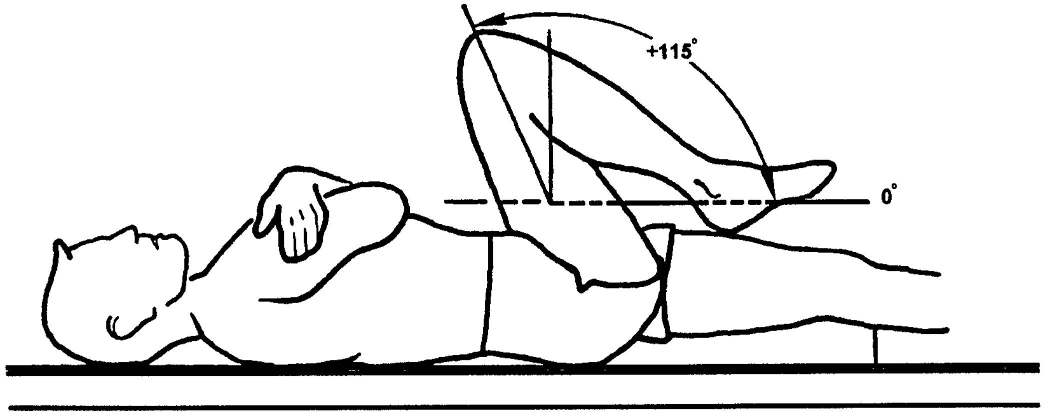


Elbow Flexion

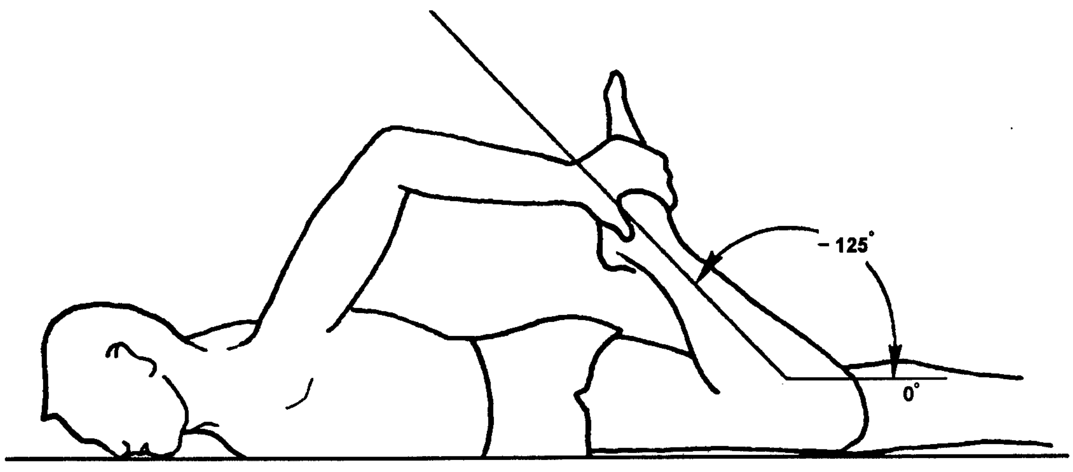


Knee Medial/Lateral Rotation
(A - Medial; B - Lateral)

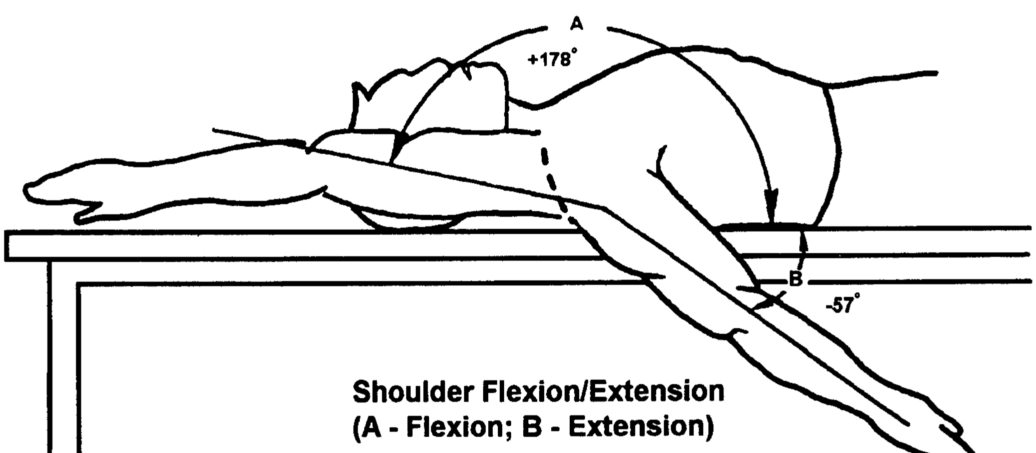
Figure E-3. Elbow Flexion and Knee Medial /Lateral Rotation



Hip Flexion

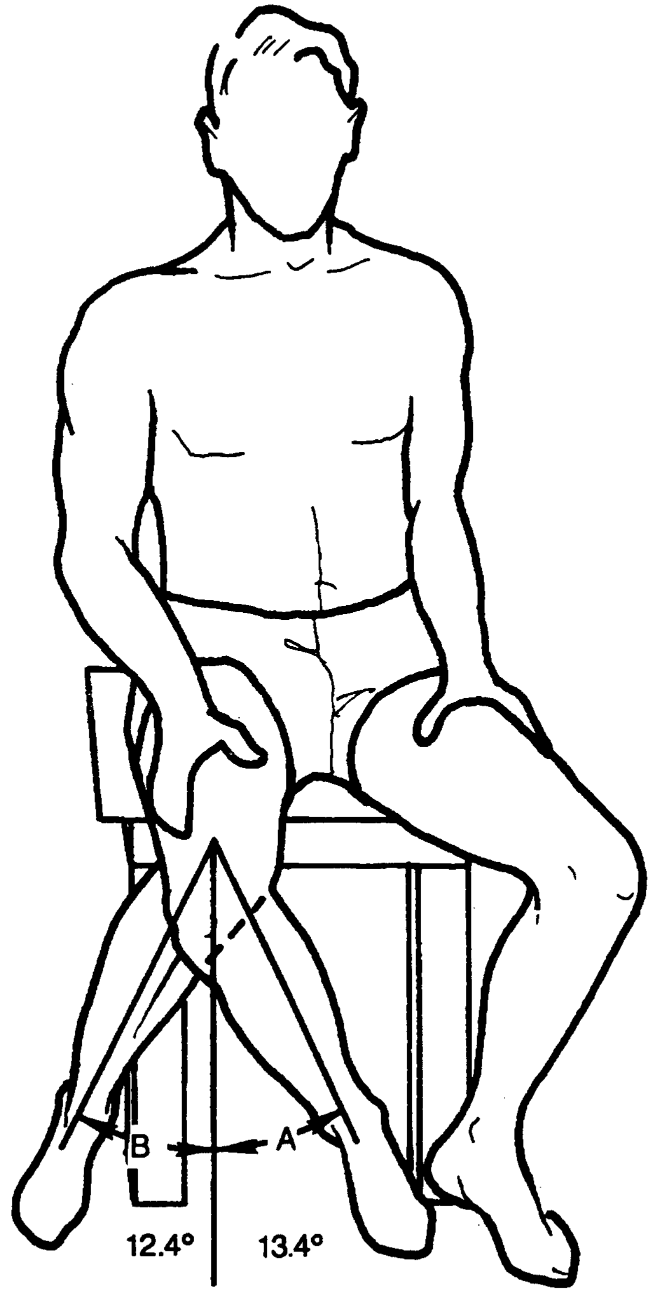


Knee Flexion



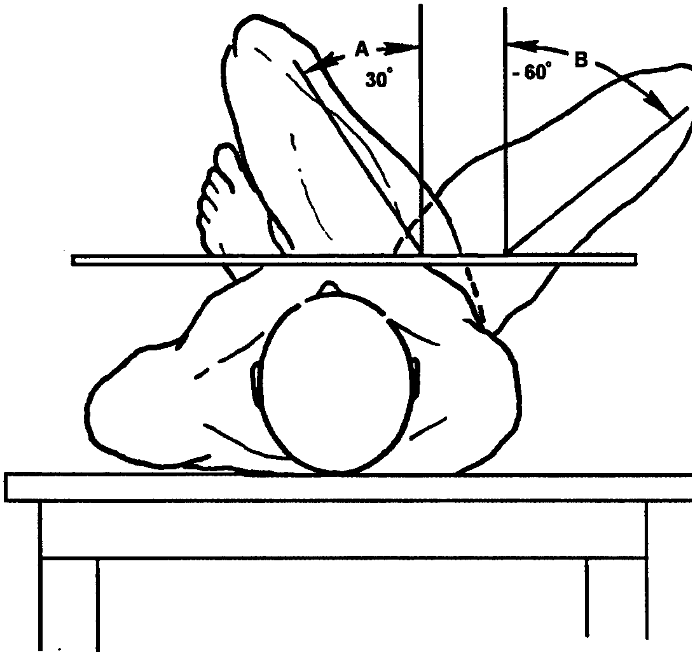
Shoulder Flexion/Extension
(A - Flexion; B - Extension)

Figure E-4. Hip Flexion, Knee Flexion and Shoulder Flexion/Extension

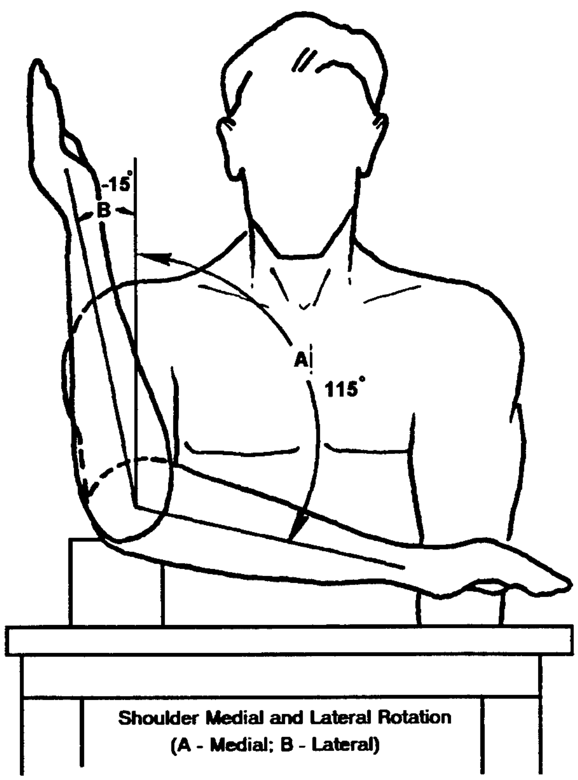


Hip Medial and Lateral Rotation
(A – Medial; B – Lateral)

Figure E-5. Hip Medial/Lateral Rotation



Hip Adduction and Abduction
(A - Adduction; B - Abduction)



Shoulder Medial and Lateral Rotation
(A - Medial; B - Lateral)

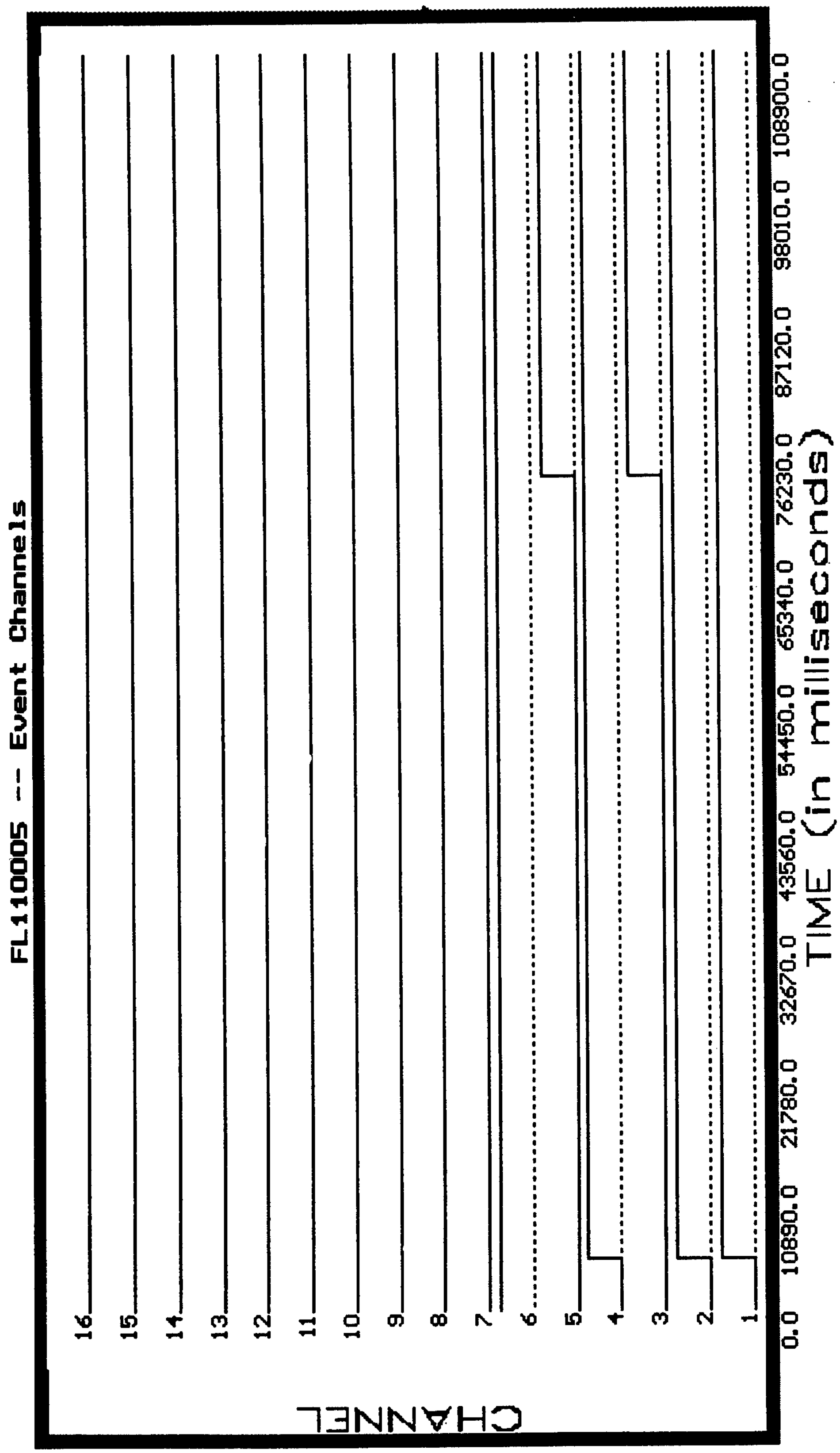
Figure E-6. Hip Abduction/Adduction and Shoulder Medial/Lateral Rotation

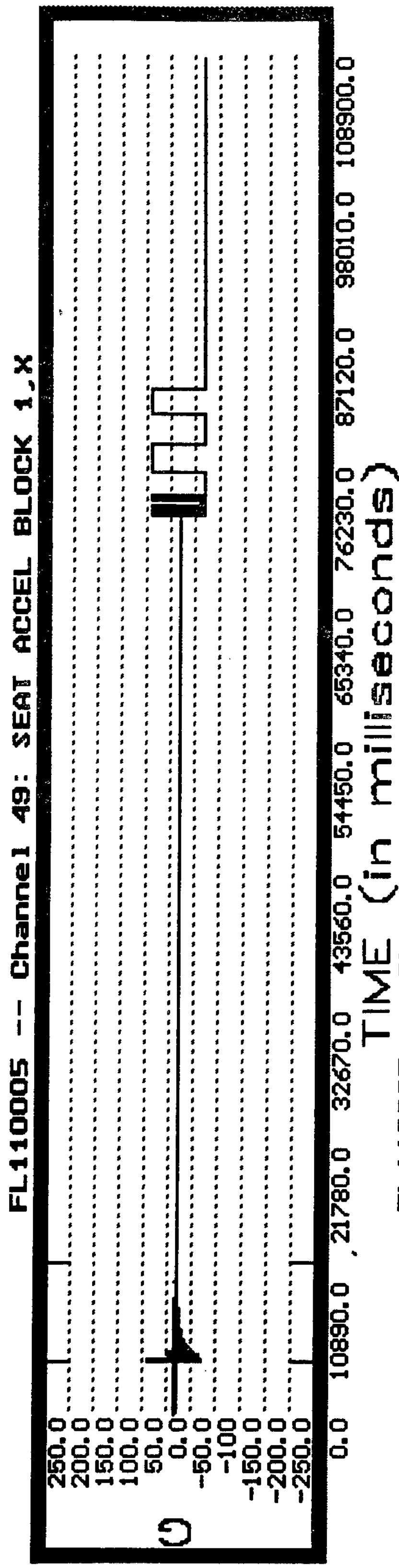
Appendix F

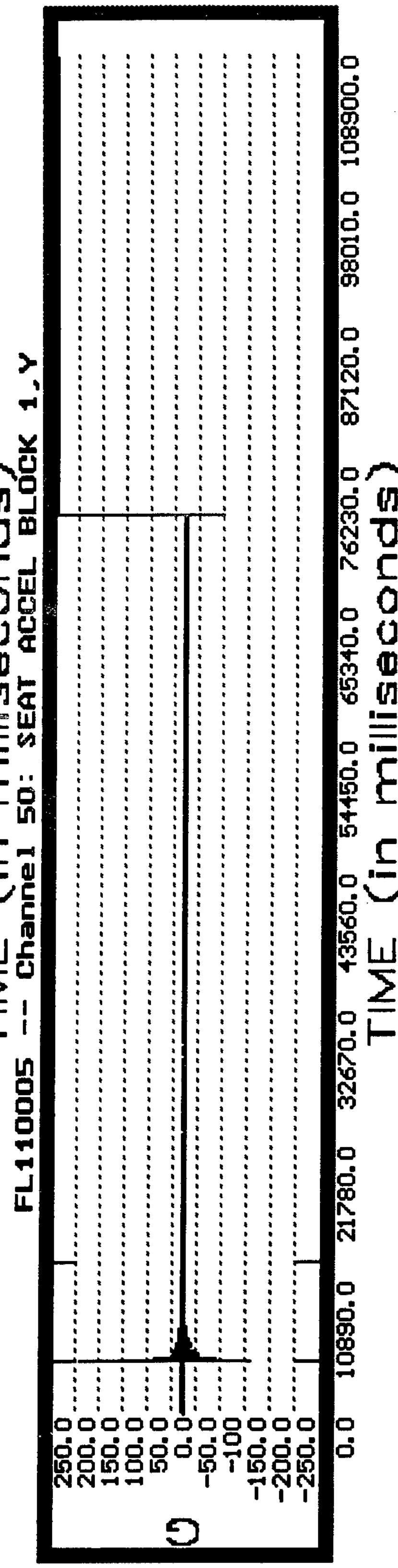
Sample of Raw Data

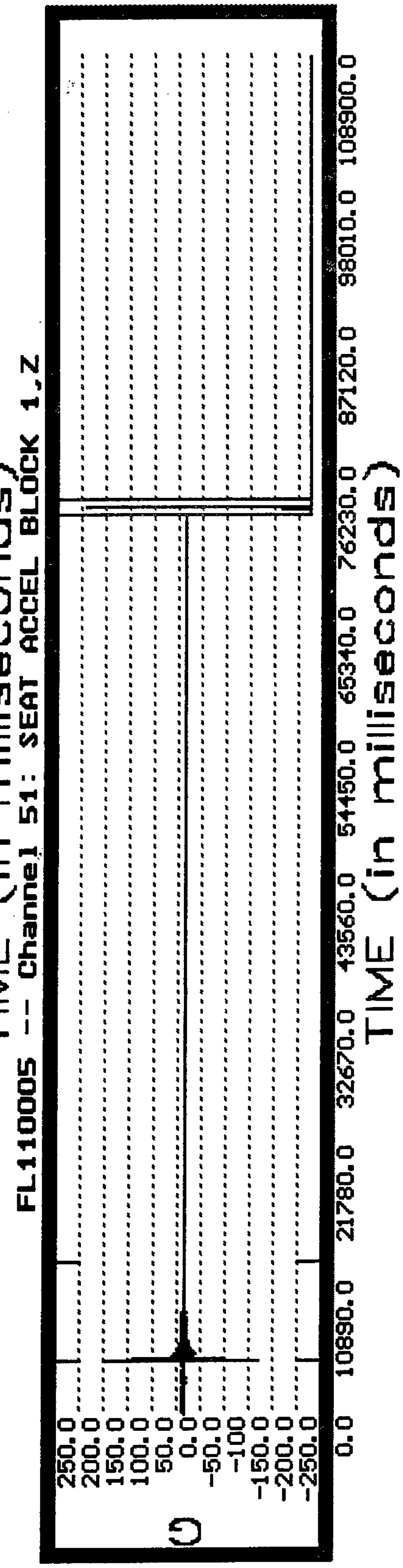
FL110005

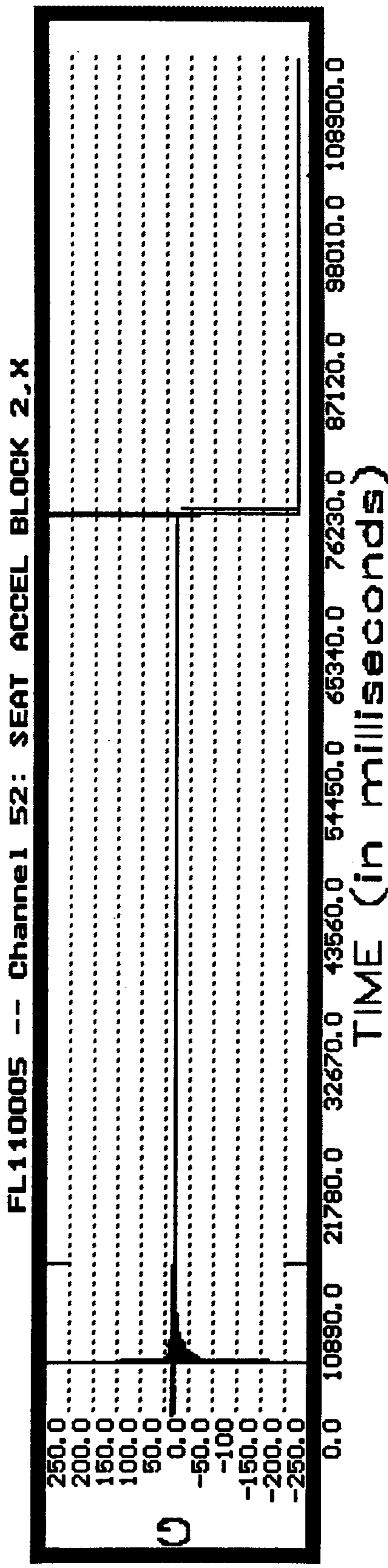
Event Channels
Seat Accelerations, #1
Seat Accelerations, #2
Seat Accelerations, #3
Seat Accelerations, #4
Seat Angular Rates
Head Accelerations
Chest Accelerations
Lumbar Accelerations
Neck Forces
Neck Moments
Lumbar Forces
Lumbar Moments
Windblast Deflector Pressures
Visor Total, Chest Total, and Internal Static Pressures
Left Leg Force
Right Leg Force
Parachute Riser Force
Arm Lift
Manikin Temperature, Ground Signal
Hip Abduction/Adduction
Hip Flexion
Knee Flexion
Shoulder Flexion
Shoulder Medial/Lateral Rotation

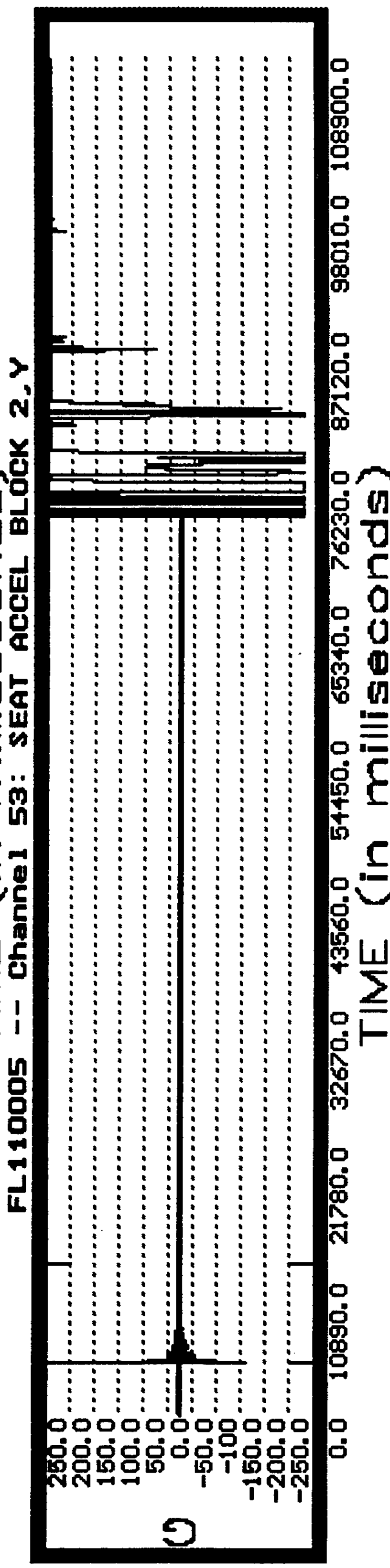

FL110005 -- Event Channels
CHANNEL
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)

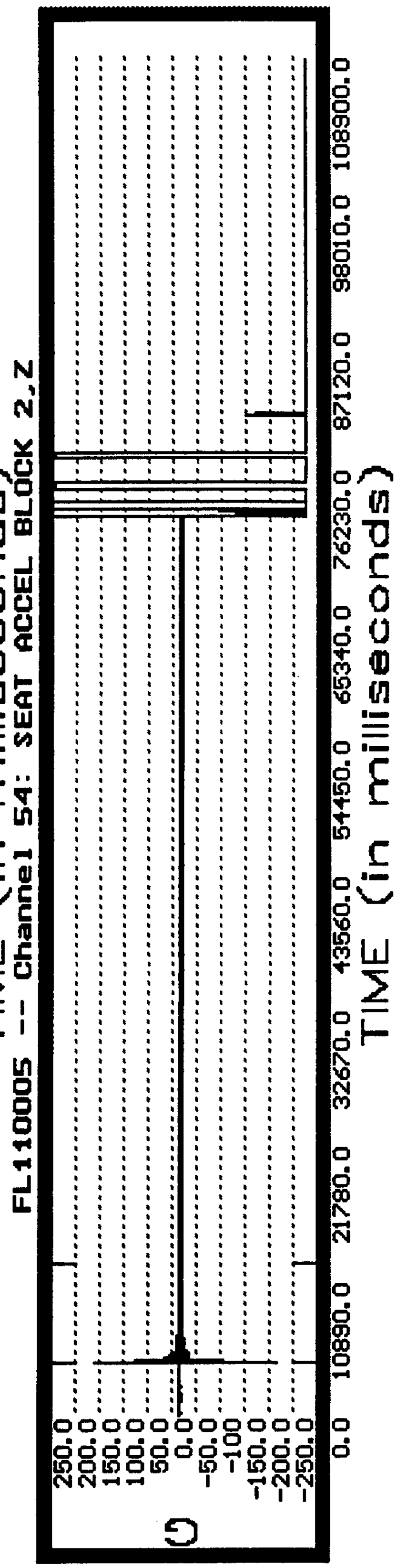

FL110005 -- Channel 49: SEAT ACCEL BLOCK 1.X
G
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100
-150.0
-200.0
-250.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)


FL110005 -- Channel 50: SEAT ACCEL BLOCK 1.Y
G
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100
-150.0
-200.0
-250.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)

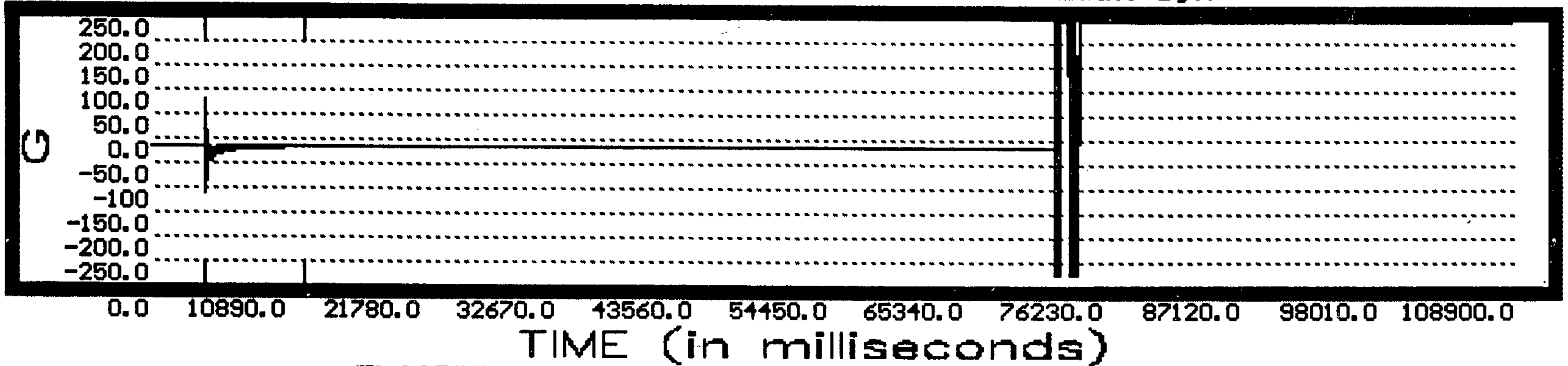

FL110005 -- Channel 51: SEAT ACCEL BLOCK 1.Z
G
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100
-150.0
-200.0
-250.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)


FL110005 -- Channel 52: SEAT ACCEL BLOCK 2,X
G
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100
-150.0
-200.0
-250.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

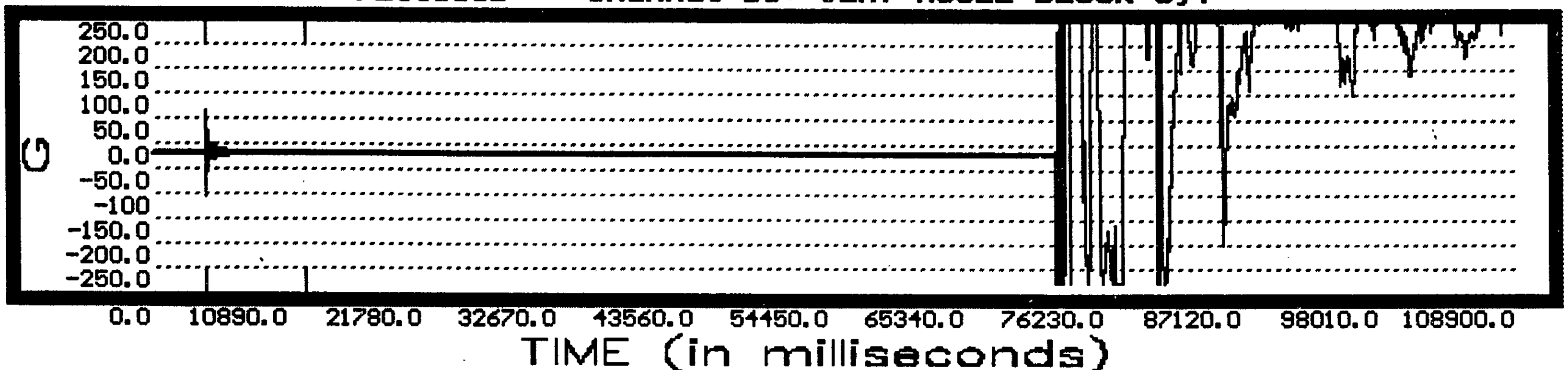

FL110005 -- Channel 53: SEAT ACCEL BLOCK 2,Y
G
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100
-150.0
-200.0
-250.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)


FL110005 -- Channel 54: SEAT ACCEL BLOCK 2,Z
G
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100
-150.0
-200.0
-250.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

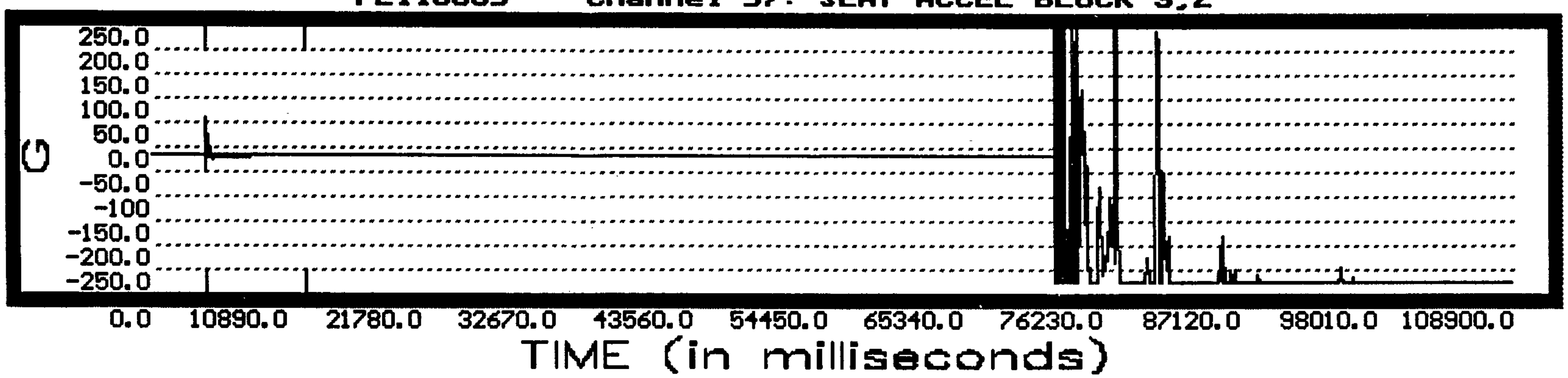
FL110005 -- Channel 55: SEAT ACCEL BLOCK 3,X



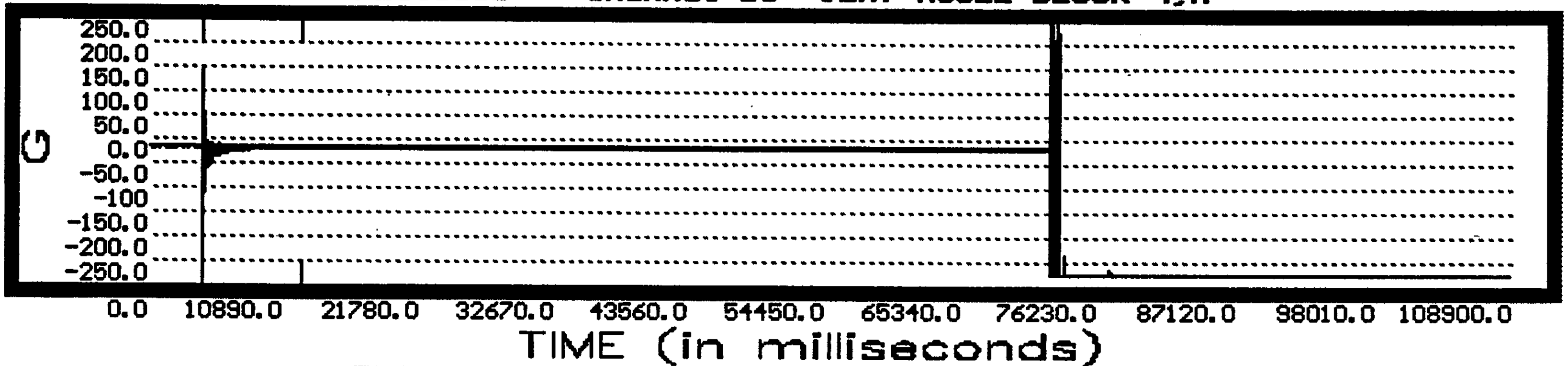
FL110005 -- Channel 56: SEAT ACCEL BLOCK 3,Y



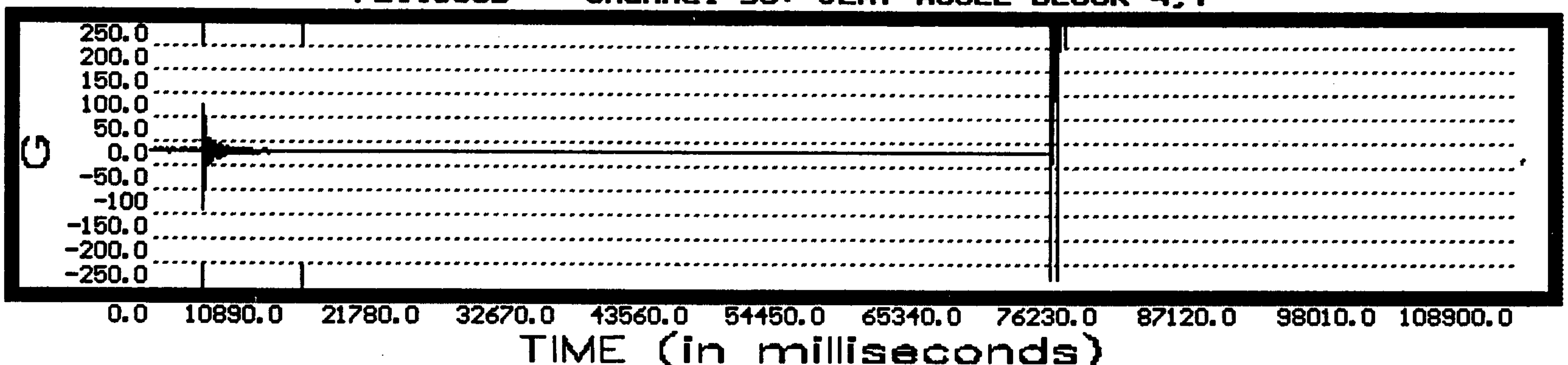
FL110005 -- Channel 57: SEAT ACCEL BLOCK 3,Z



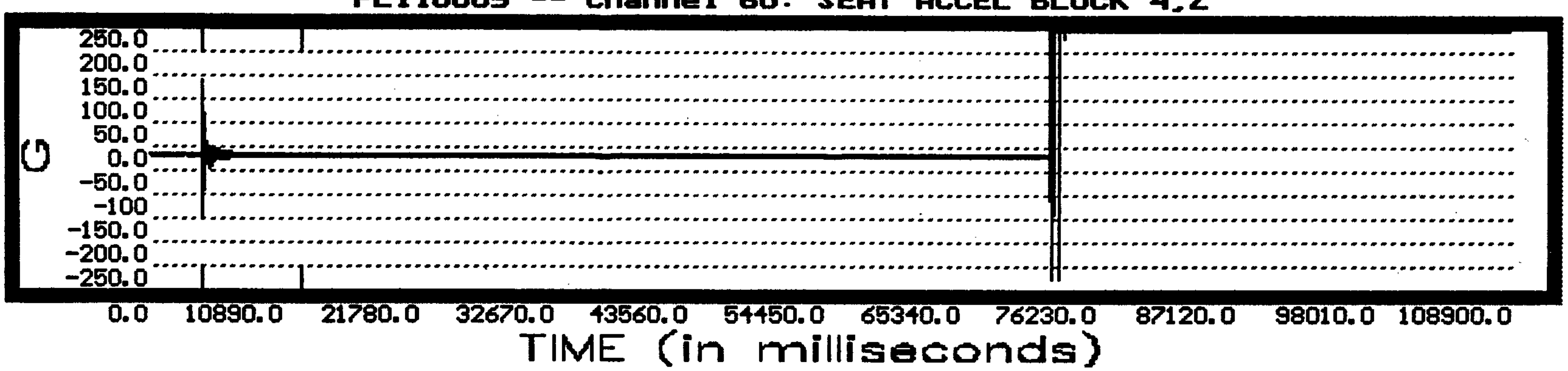
FL110005 -- Channel 58: SEAT ACCEL BLOCK 4.X



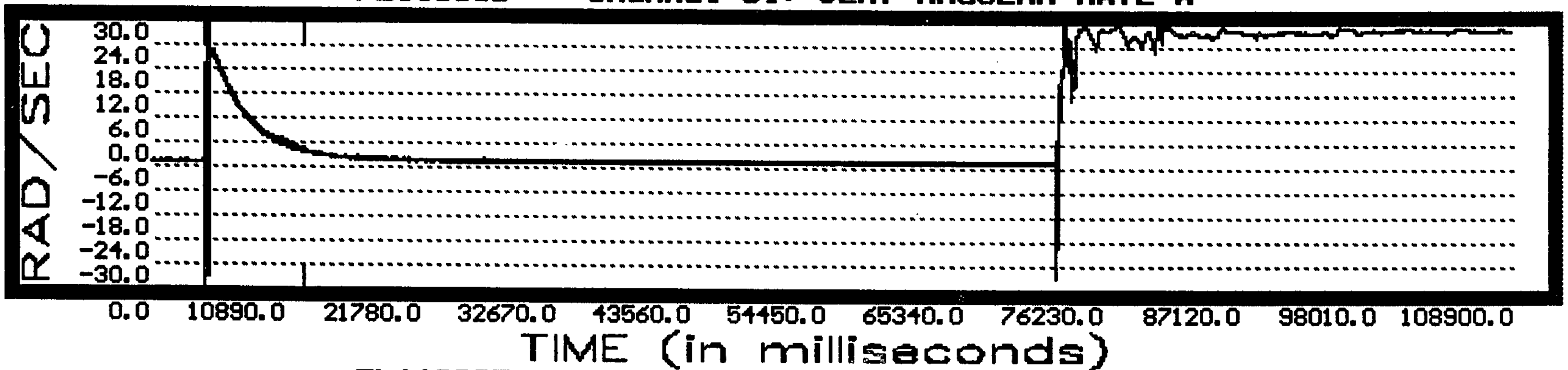
FL110005 -- Channel 59: SEAT ACCEL BLOCK 4.Y



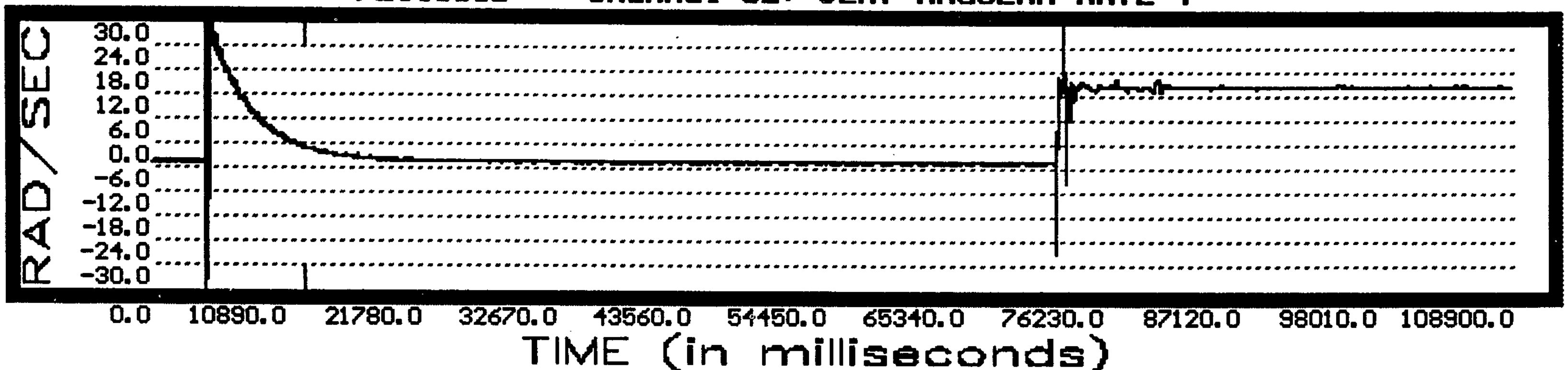
FL110005 -- Channel 60: SEAT ACCEL BLOCK 4.Z



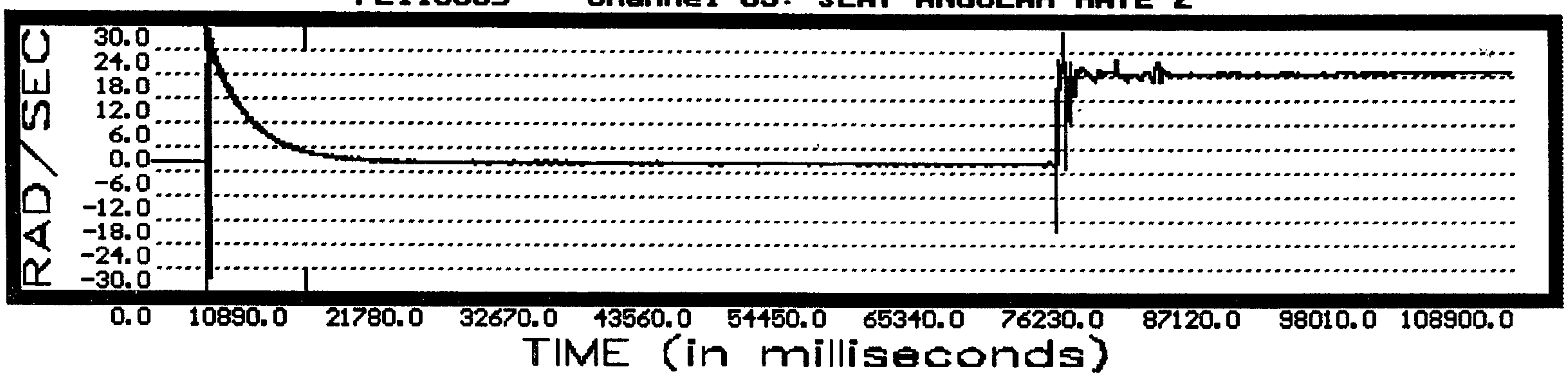
FL110005 -- Channel 61: SEAT ANGULAR RATE X



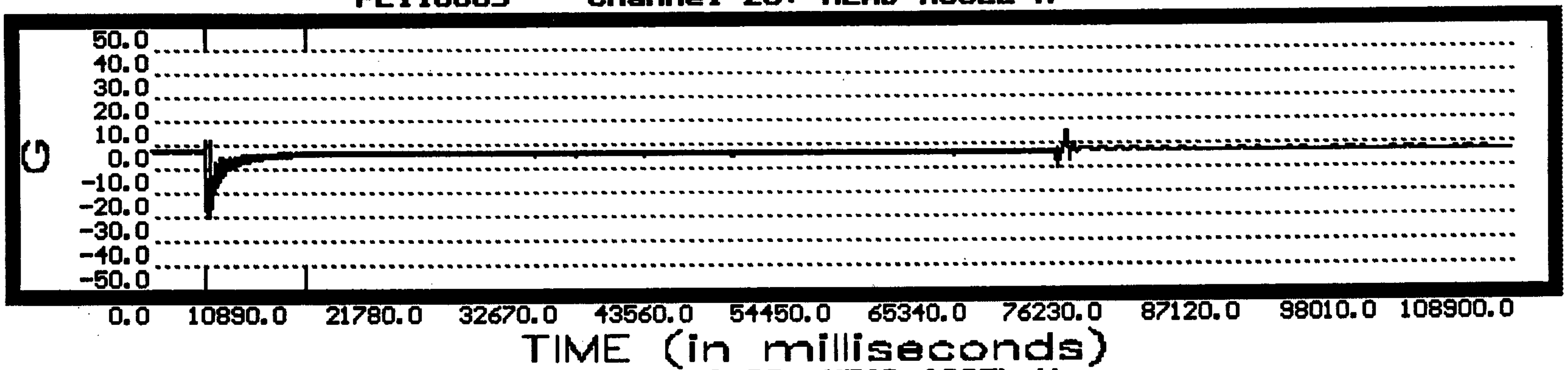
FL110005 -- Channel 62: SEAT ANGULAR RATE Y



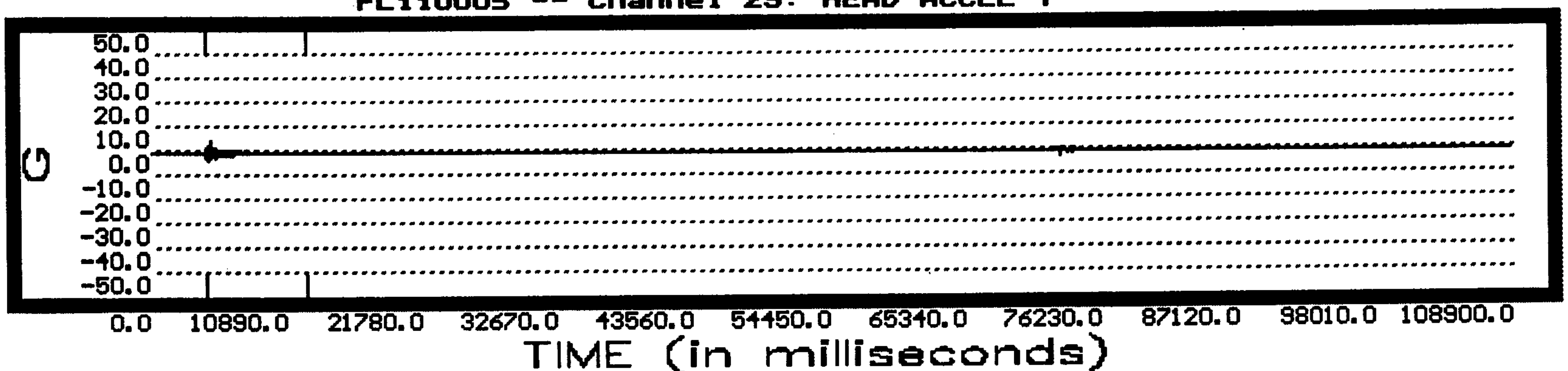
FL110005 -- Channel 63: SEAT ANGULAR RATE Z



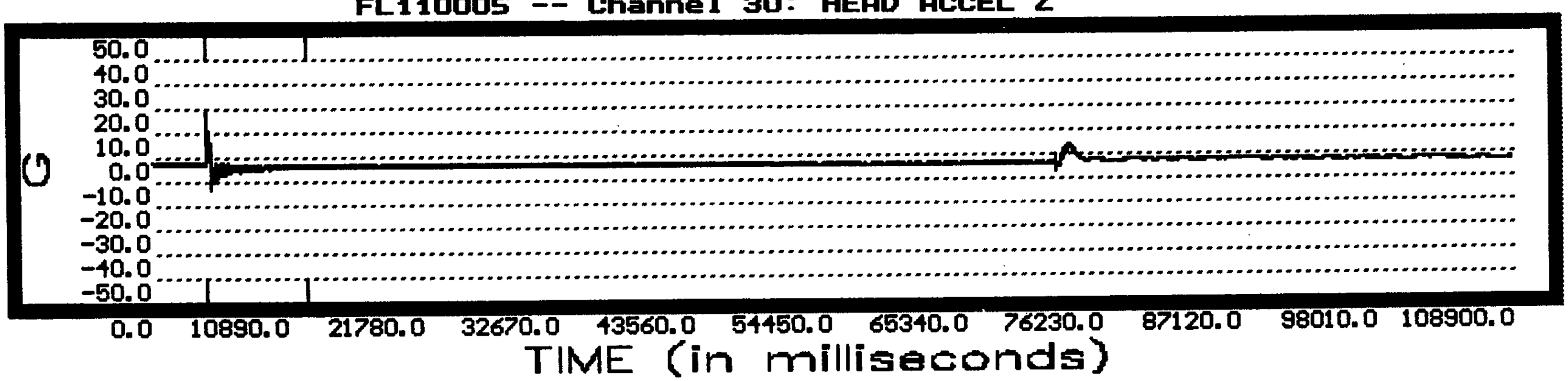
FL110005 -- Channel 28: HEAD ACCEL X

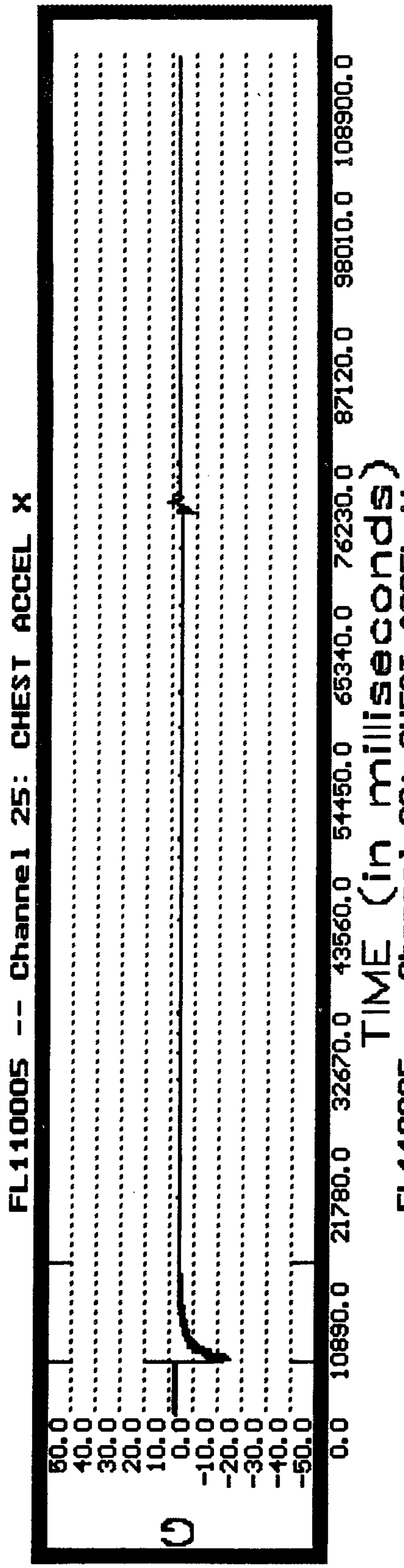


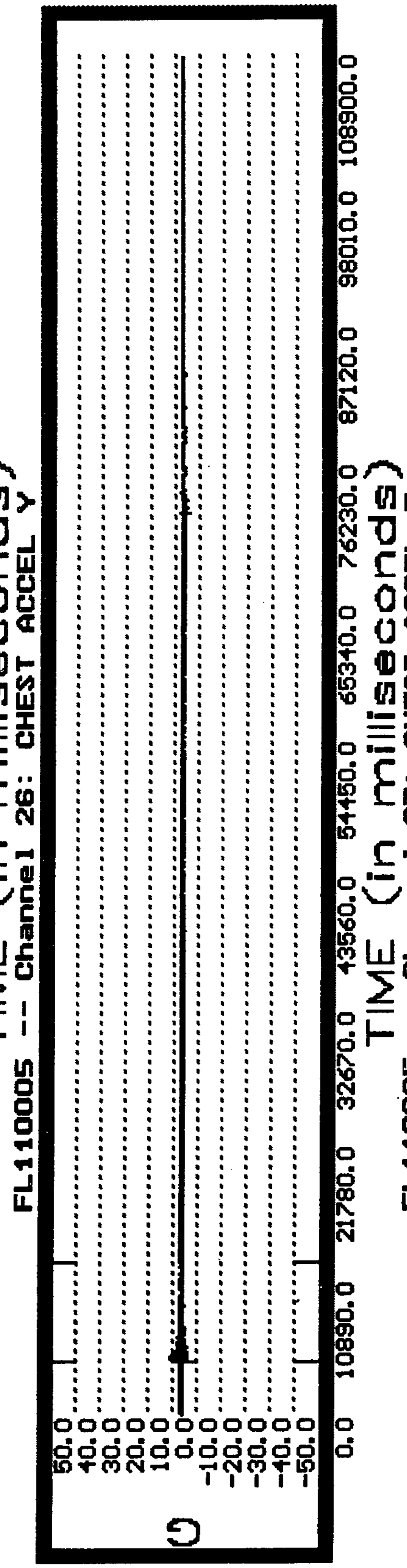
FL110005 -- Channel 29: HEAD ACCEL Y

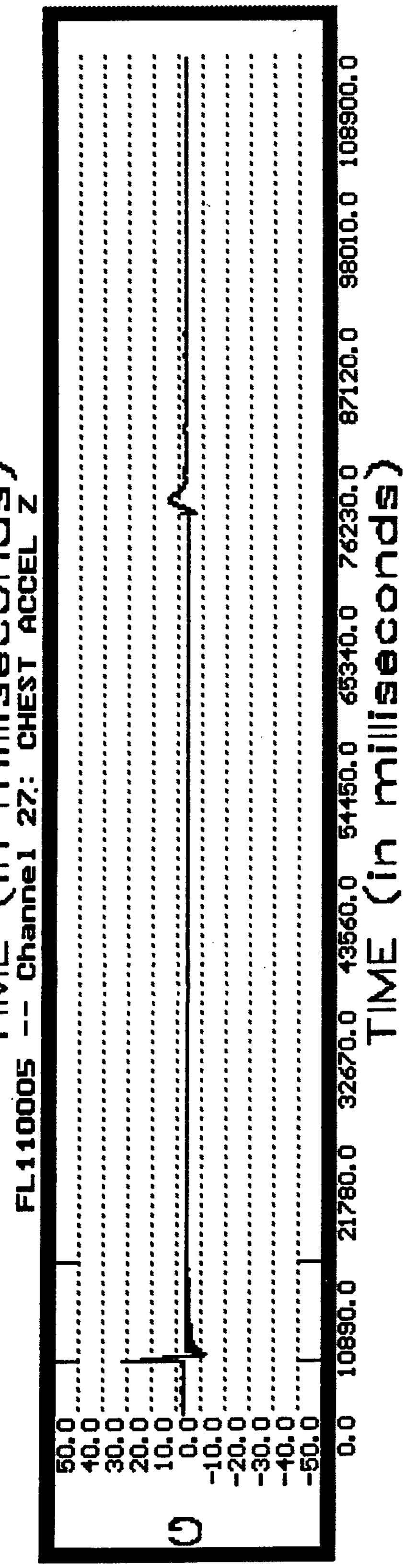


FL110005 -- Channel 30: HEAD ACCEL Z

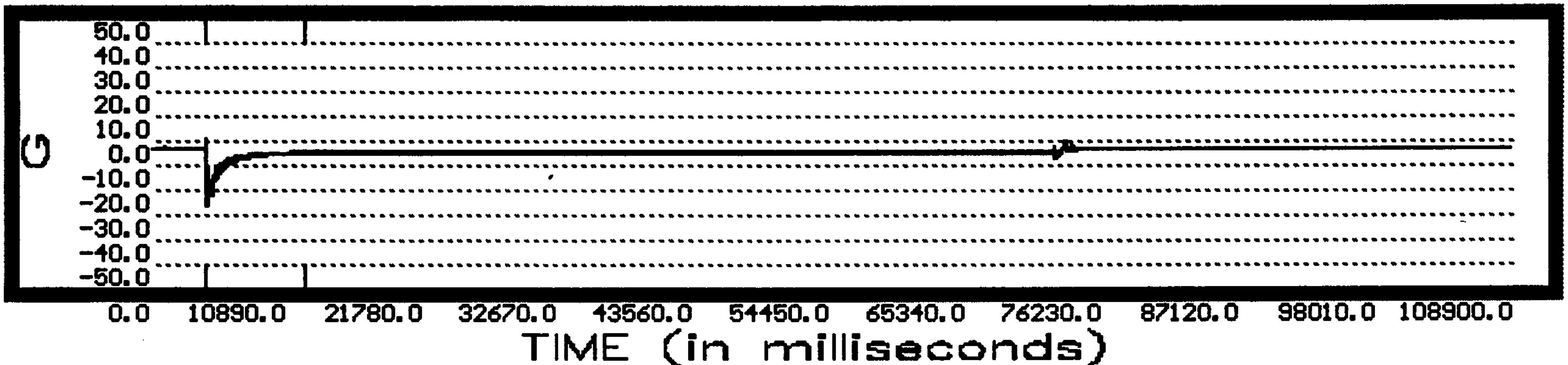



FL110005 -- Channel 25: CHEST ACCEL X
G
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

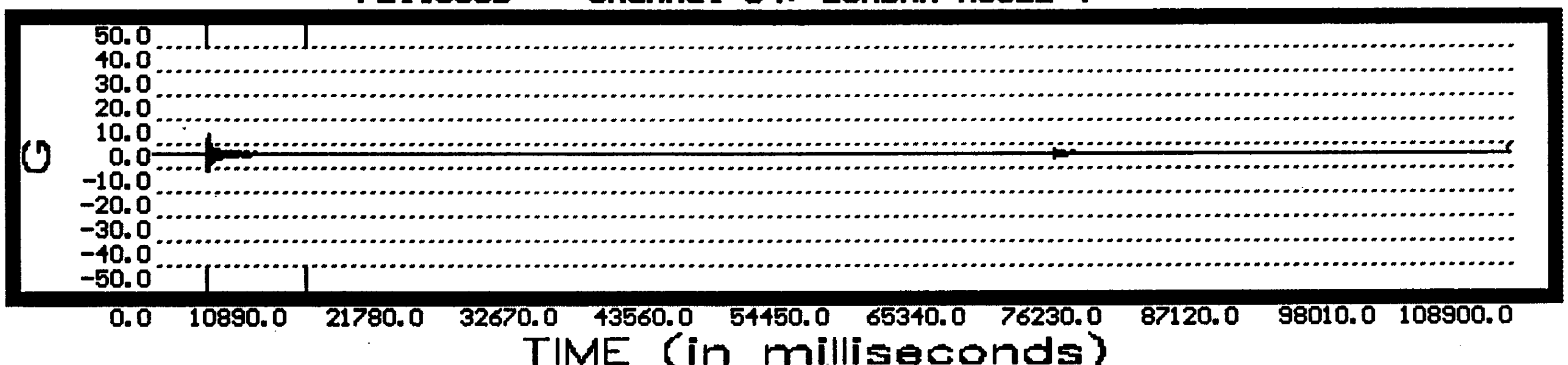

FL110005 -- Channel 26: CHEST ACCEL Y
G
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)


FL110005 -- Channel 27: CHEST ACCEL Z
G
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

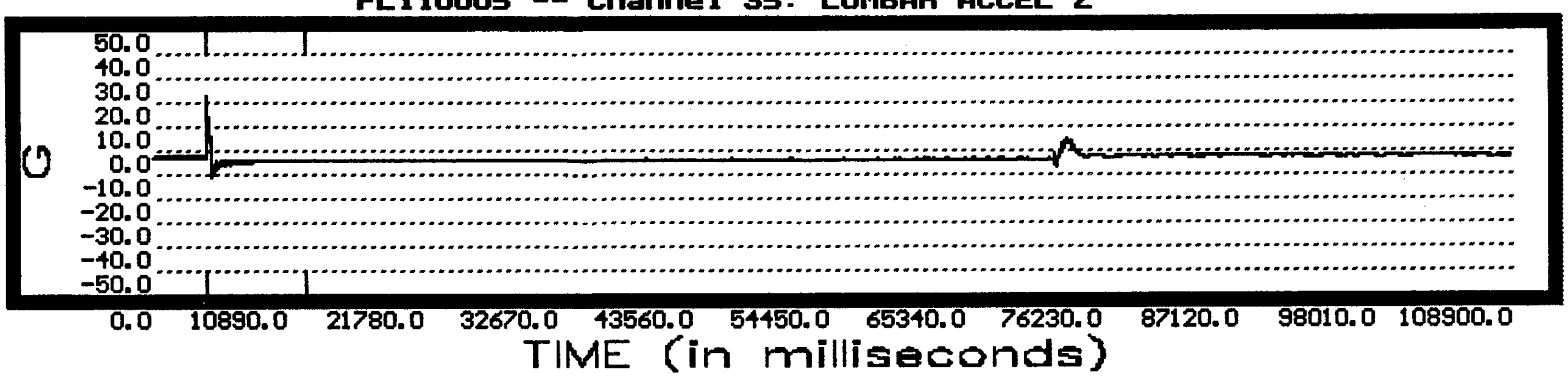
FL110005 -- Channel 33: LUMBAR ACCEL X



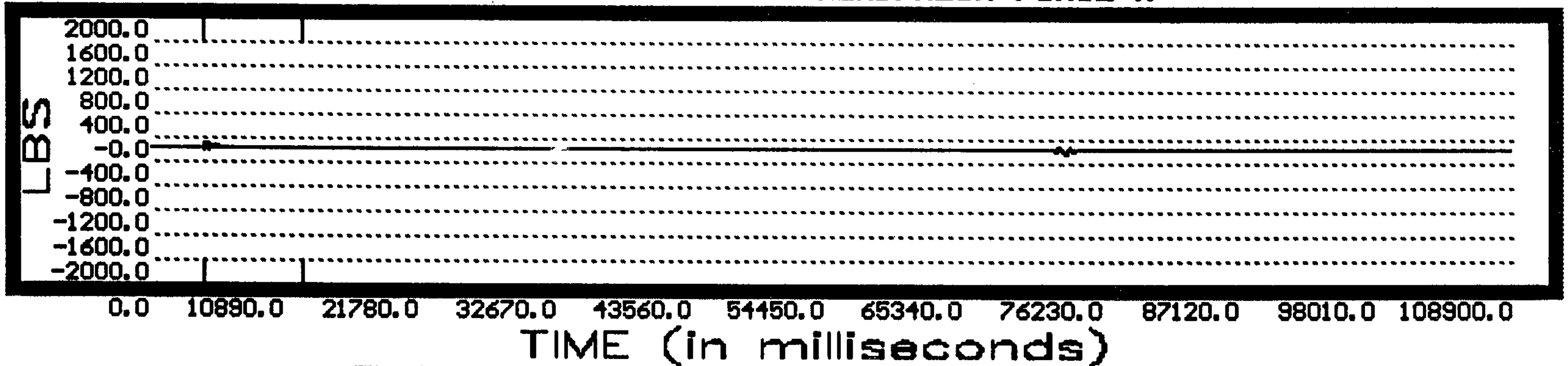
FL110005 -- Channel 34: LUMBAR ACCEL Y



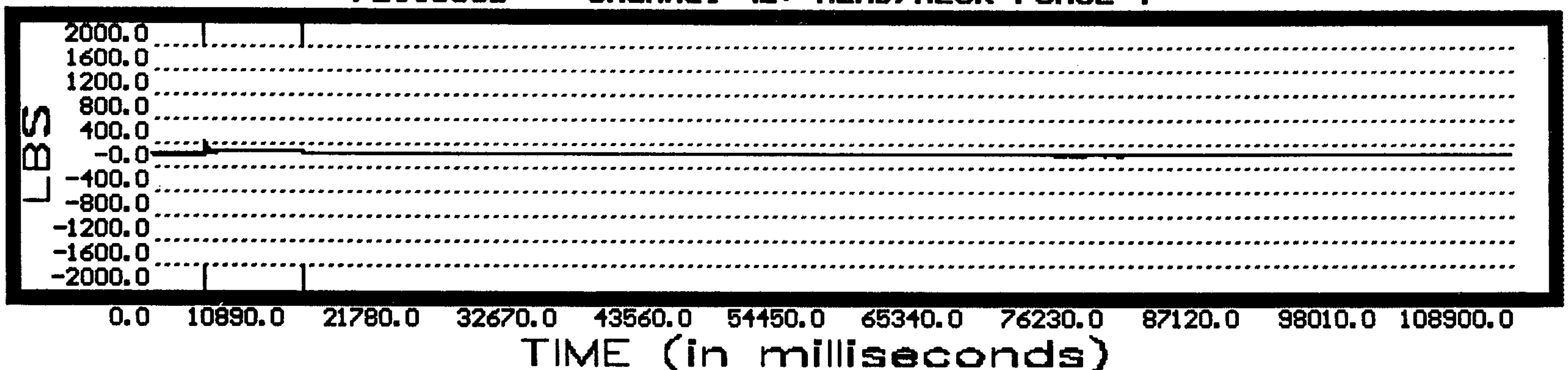
FL110005 -- Channel 35: LUMBAR ACCEL Z



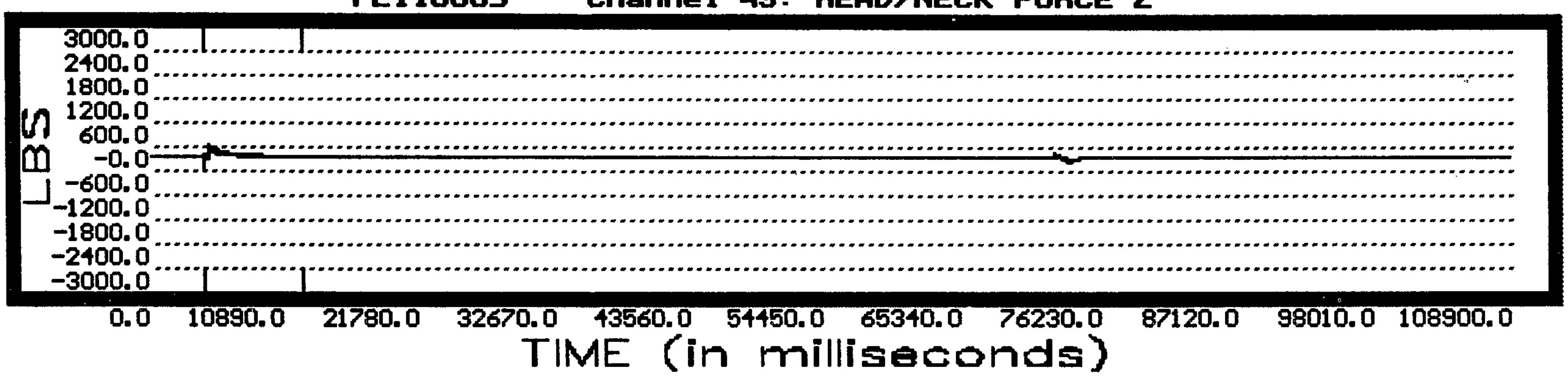
FL110005 -- Channel 41: HEAD/NECK FORCE X



FL110005 -- Channel 42: HEAD/NECK FORCE Y



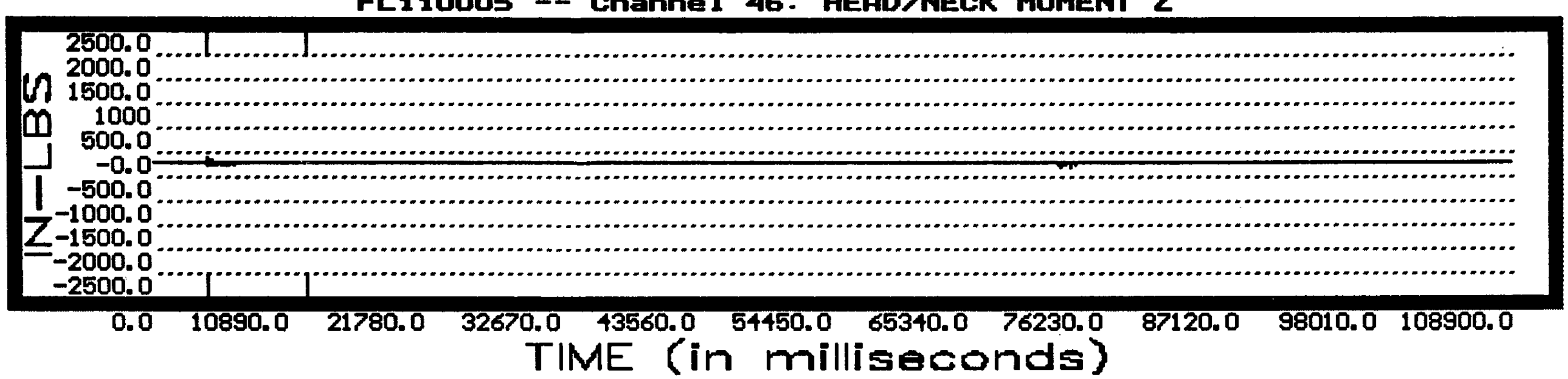
FL110005 -- Channel 43: HEAD/NECK FORCE Z



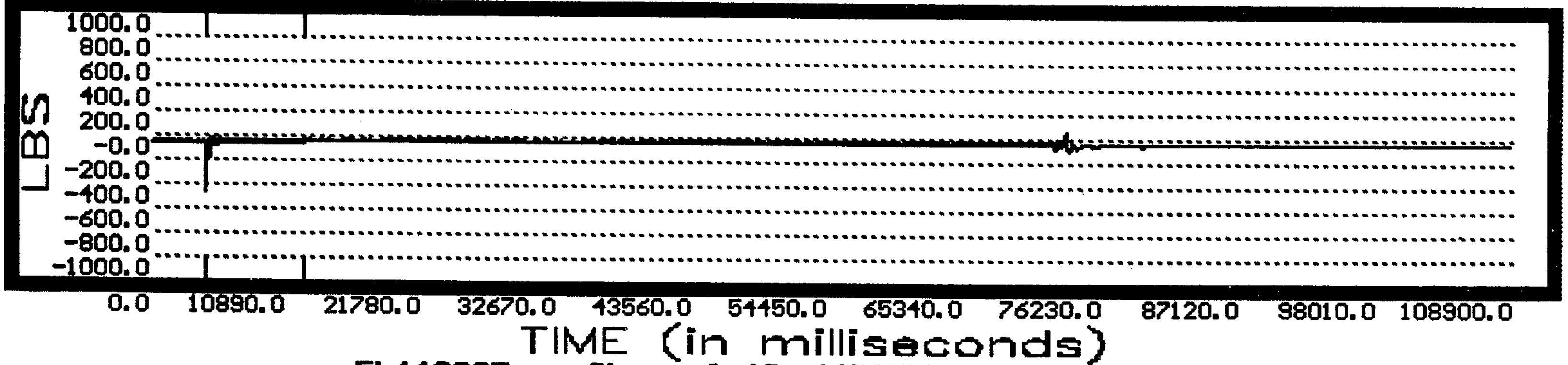
FL110005 -- Channel 44: HEAD/NECK MOMENT X

FL110005 -- Channel 45: HEAD/NECK MOMENT Y

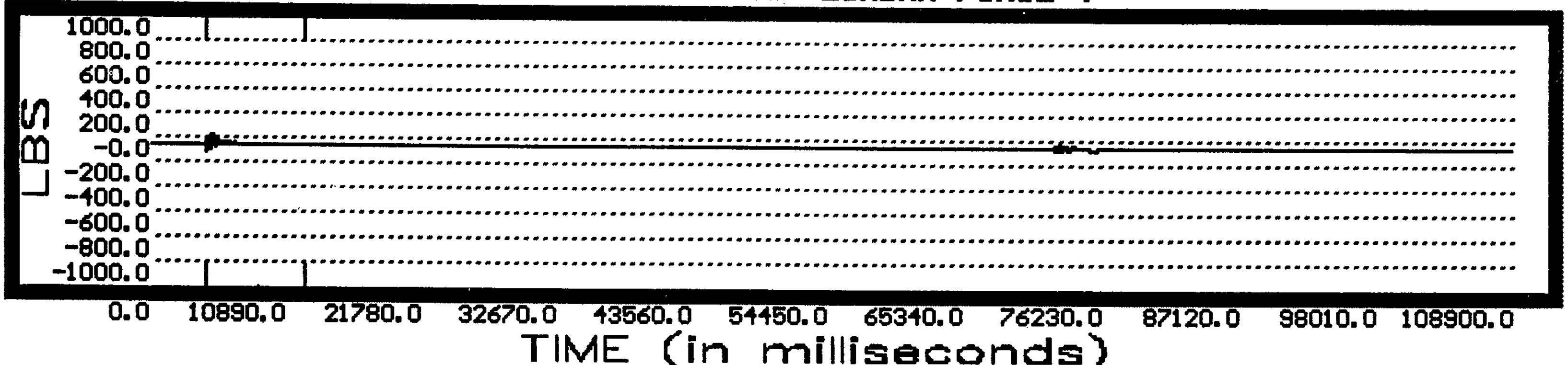
FL110005 -- Channel 46: HEAD/NECK MOMENT Z



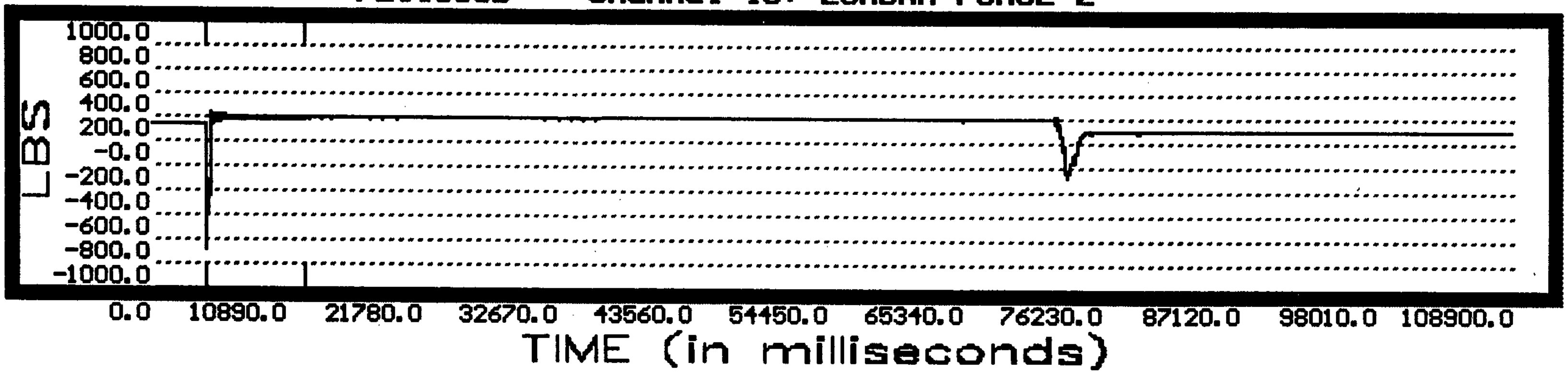
FL110005 -- Channel 17: LUMBAR FORCE X



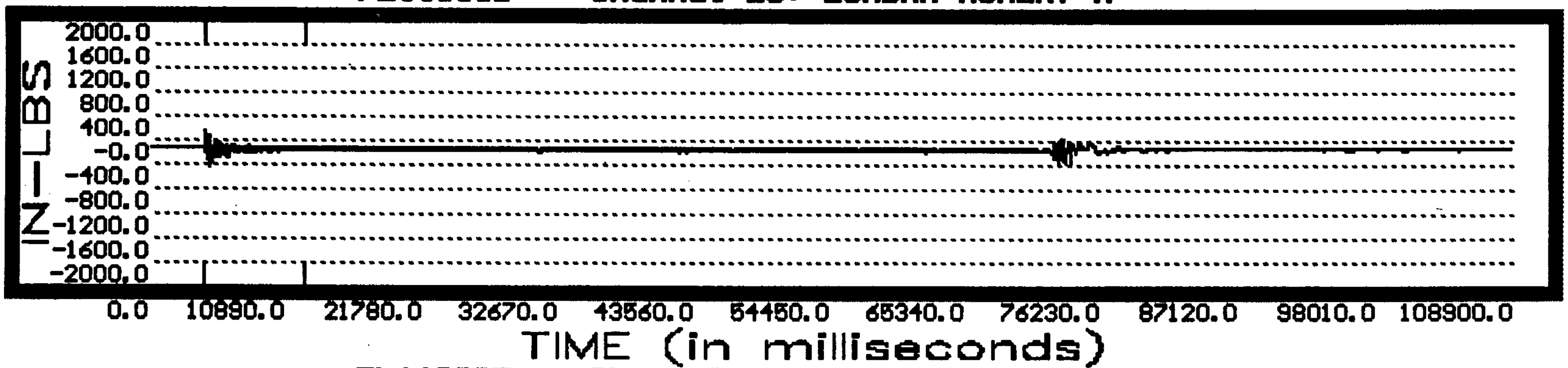
FL110005 -- Channel 18: LUMBAR FORCE Y



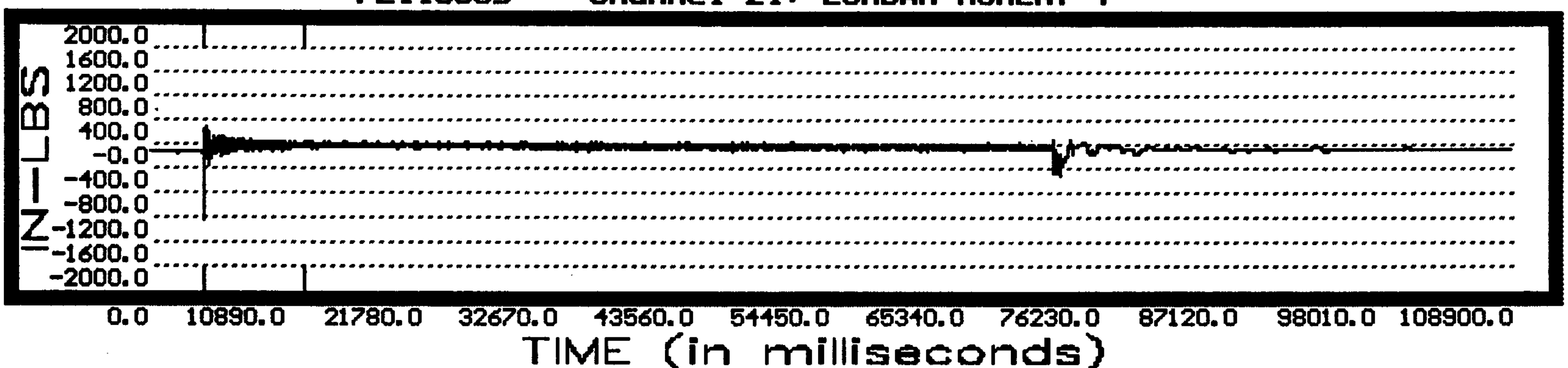
FL110005 -- Channel 19: LUMBAR FORCE Z



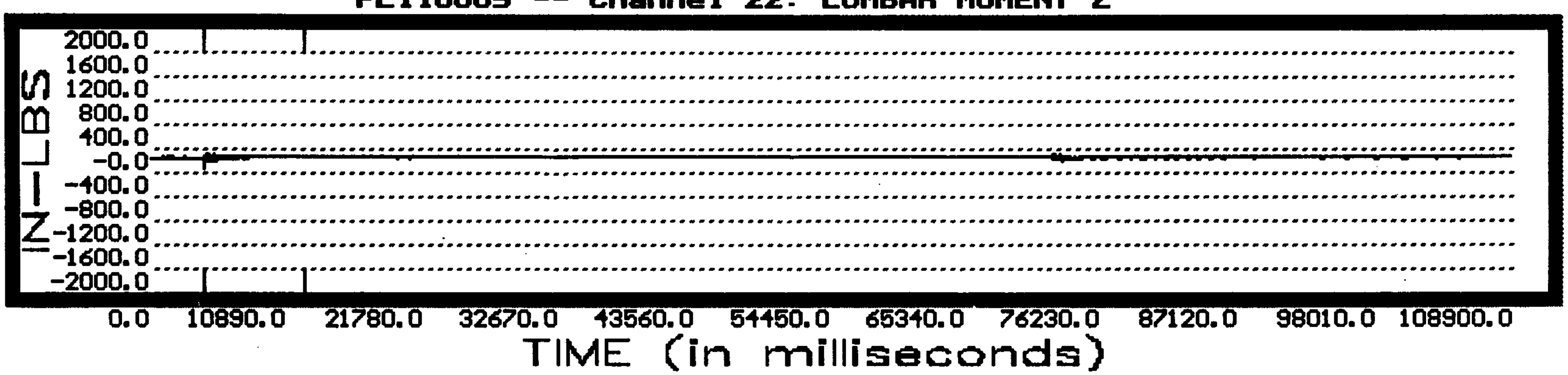
FL110005 -- Channel 20: LUMBAR MOMENT X

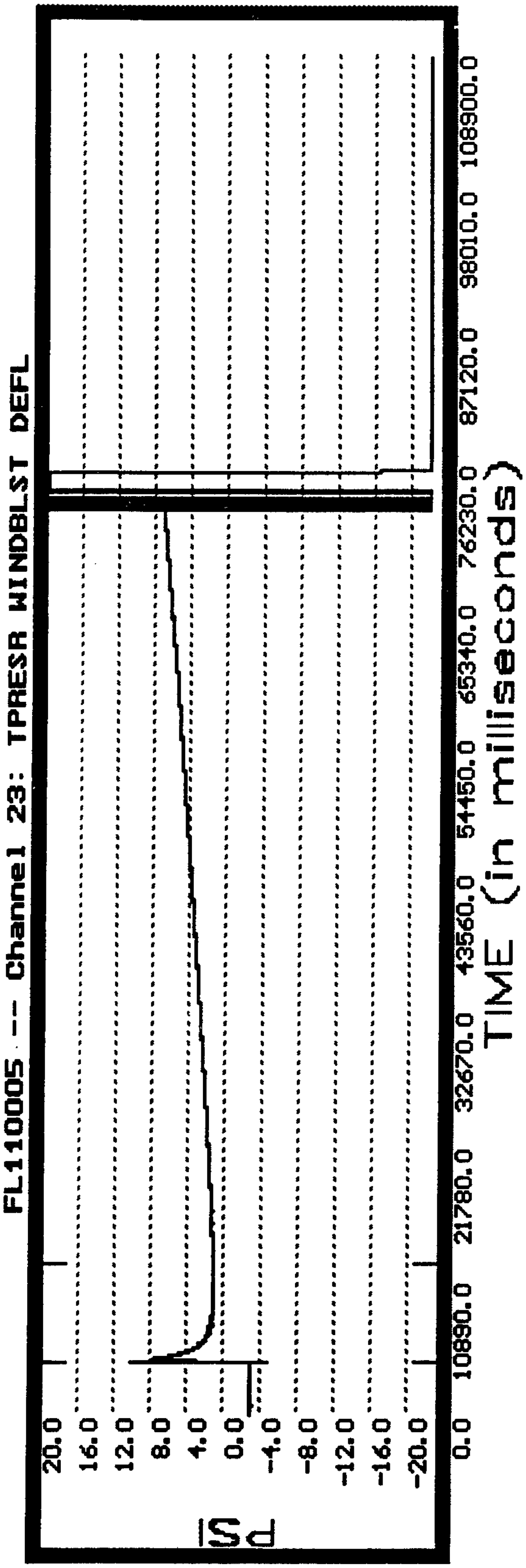


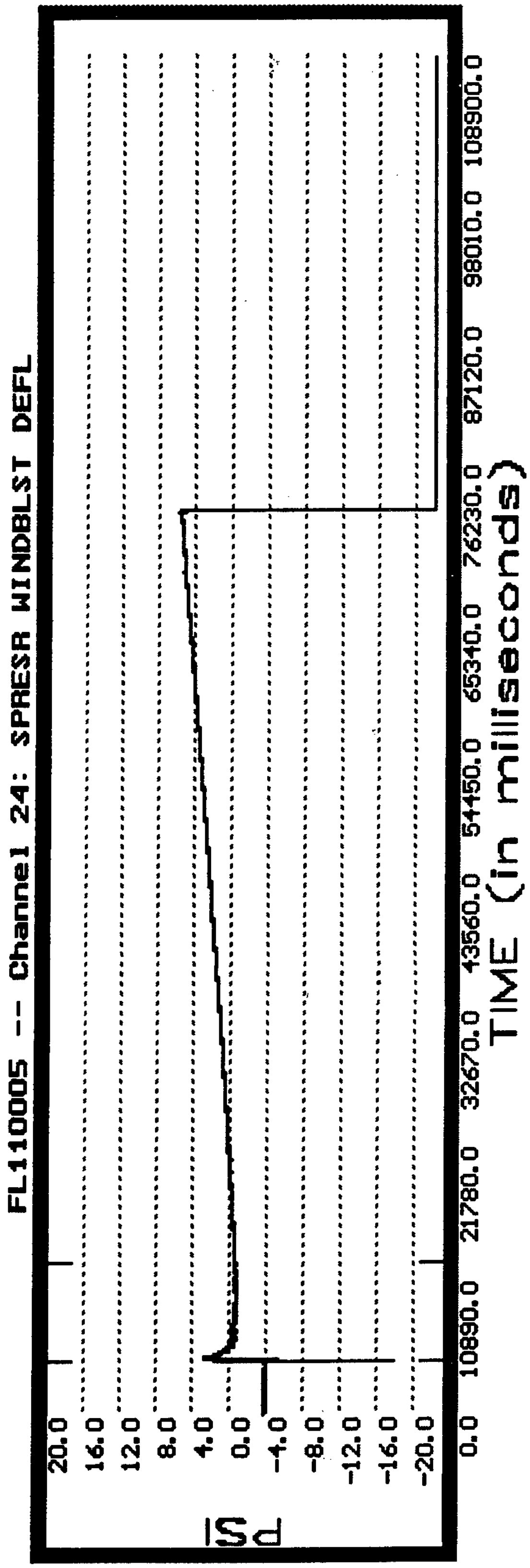
FL110005 -- Channel 21: LUMBAR MOMENT Y

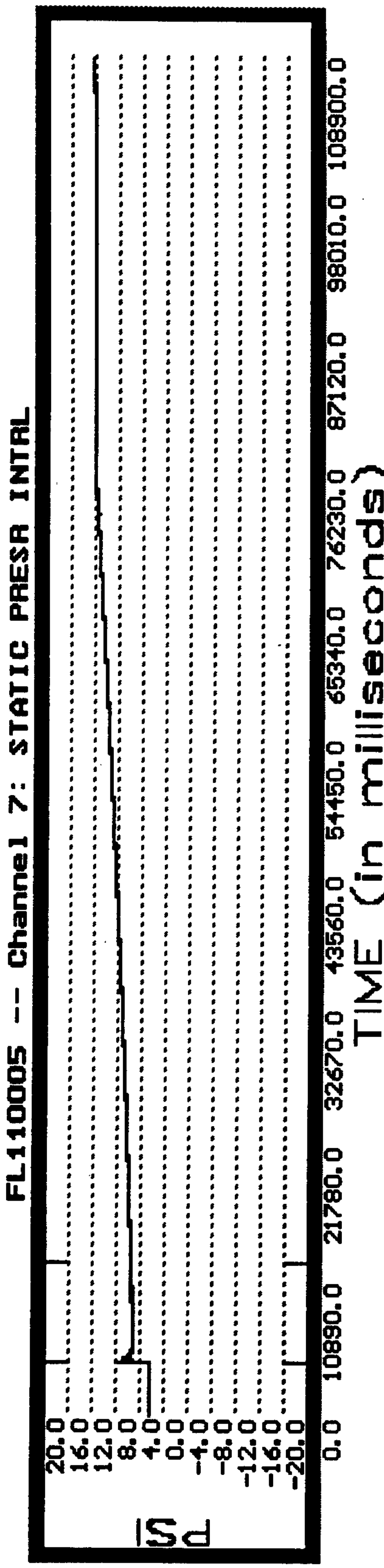


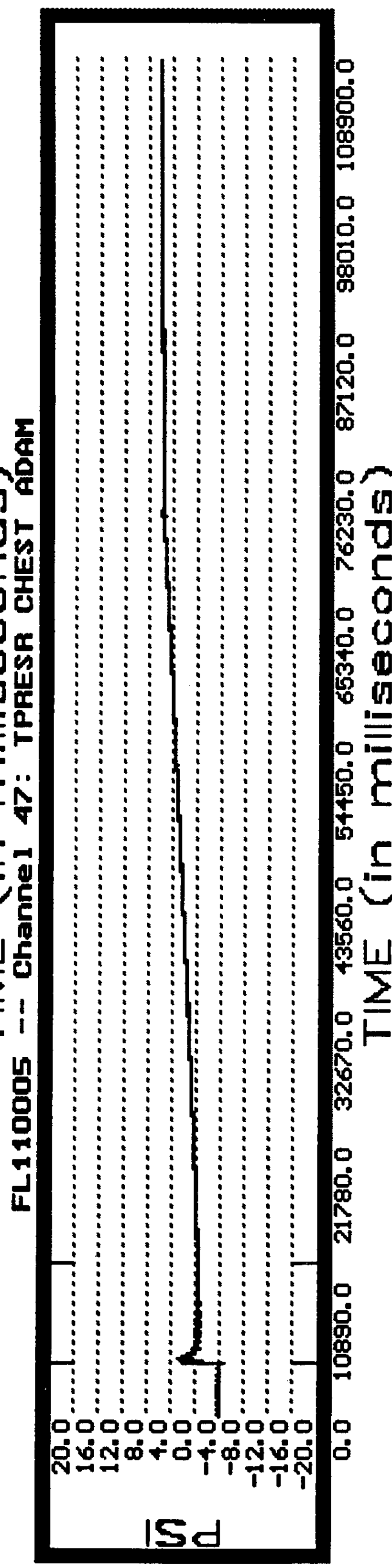
FL110005 -- Channel 22: LUMBAR MOMENT Z

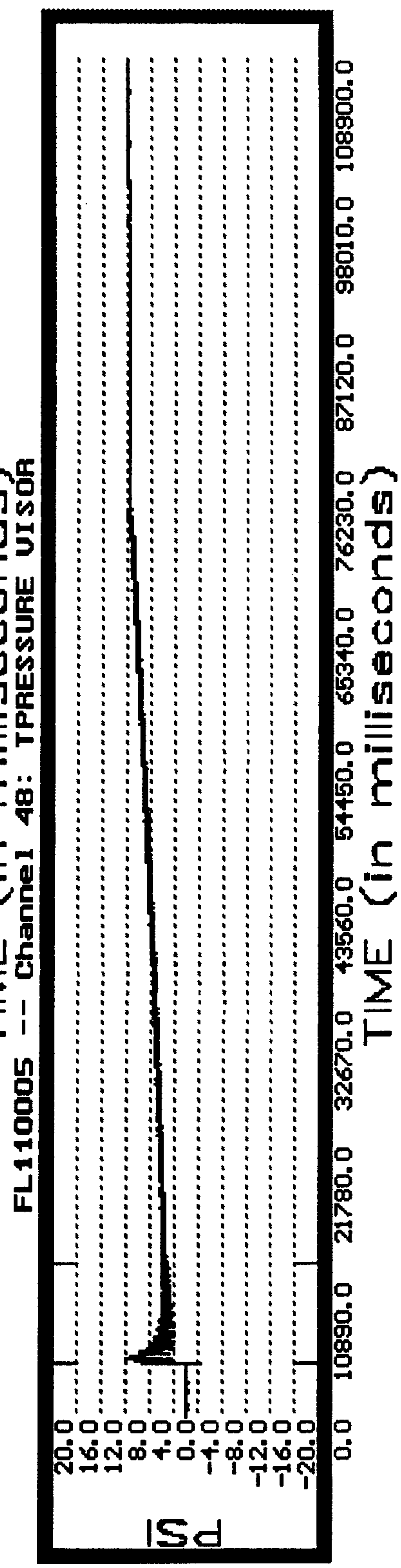


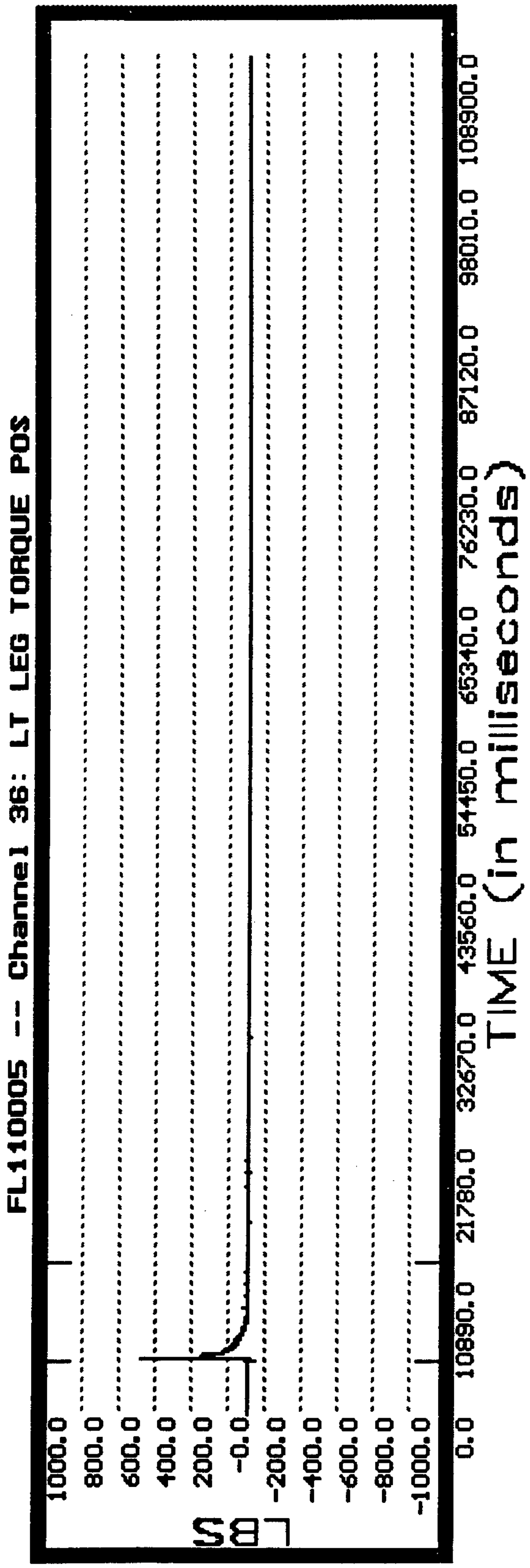

FL110005 -- Channel 23: TPRESR WINDBLST DEFL
PSI
20.0
16.0
12.0
8.0
4.0
0.0
-4.0
-8.0
-12.0
-16.0
-20.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)

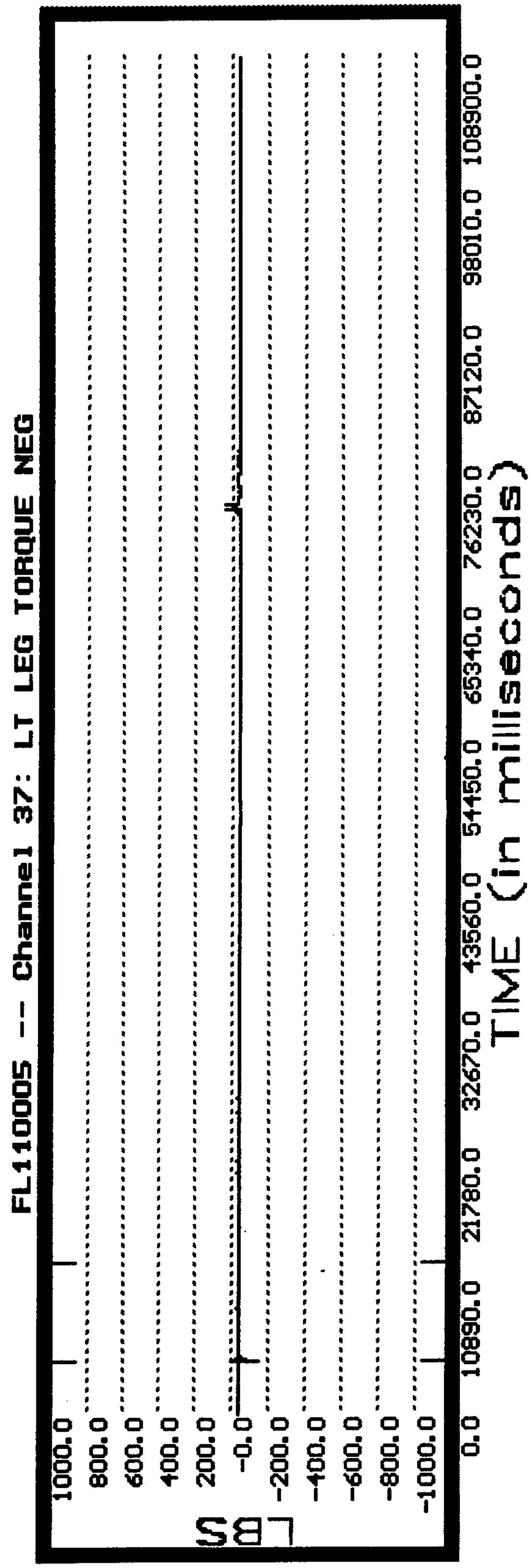

FL110005 -- Channel 24: SPRESR WINDBLST DEFL
PSI
20.0
16.0
12.0
8.0
4.0
0.0
-4.0
-8.0
-12.0
-16.0
-20.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)

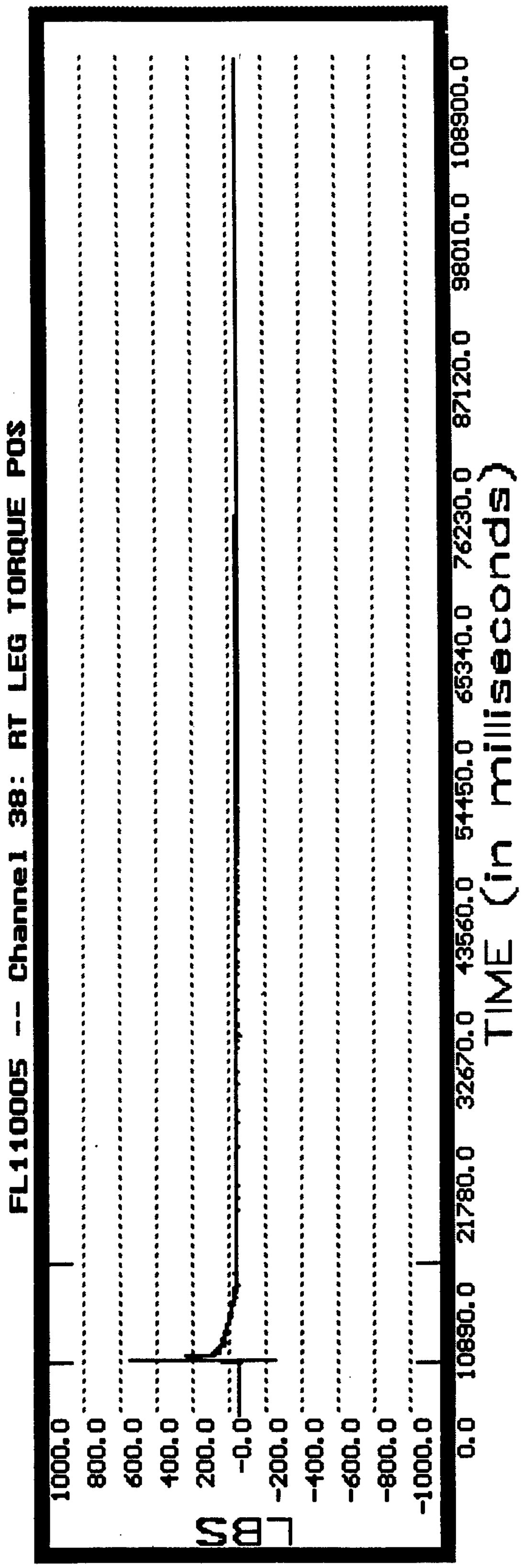

FL110005 -- Channel 7: STATIC PRESR INTRL
PSI
20.0
16.0
12.0
8.0
4.0
0.0
-4.0
-8.0
-12.0
-16.0
-20.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

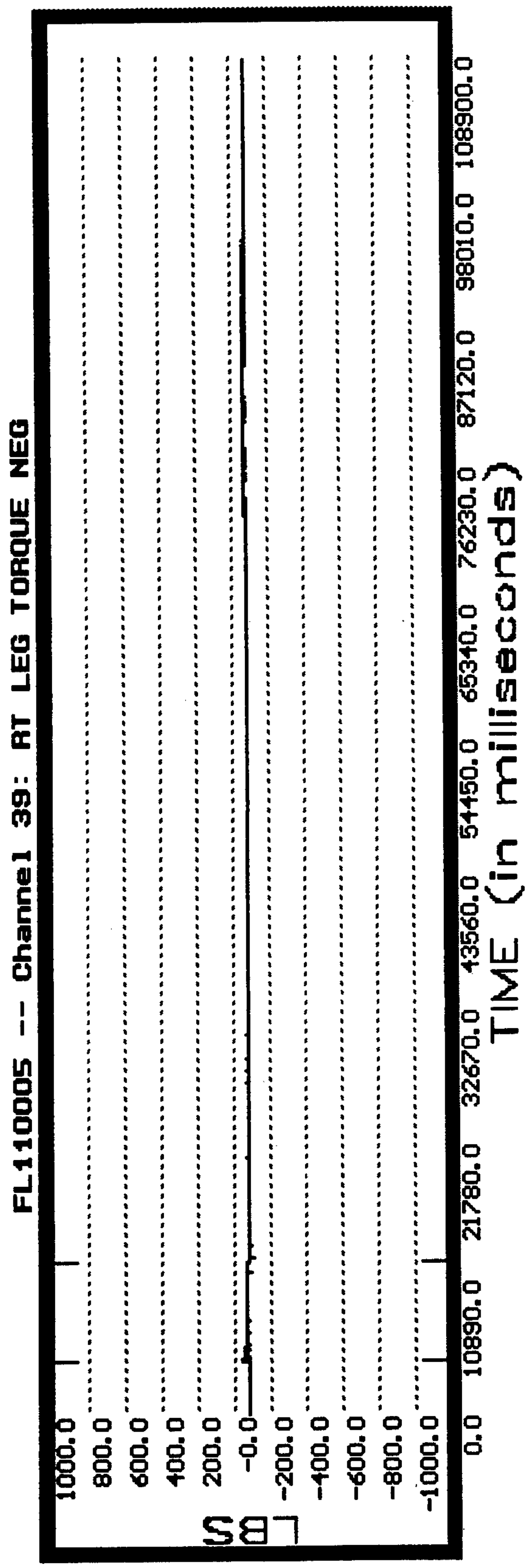

FL110005 -- Channel 47: TPRESR CHEST ADAM
PSI
20.0
16.0
12.0
8.0
4.0
0.0
-4.0
-8.0
-12.0
-16.0
-20.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)


FL110005 -- Channel 48: TPRESSURE VISOR
PSI
20.0
16.0
12.0
8.0
4.0
0.0
-4.0
-8.0
-12.0
-16.0
-20.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

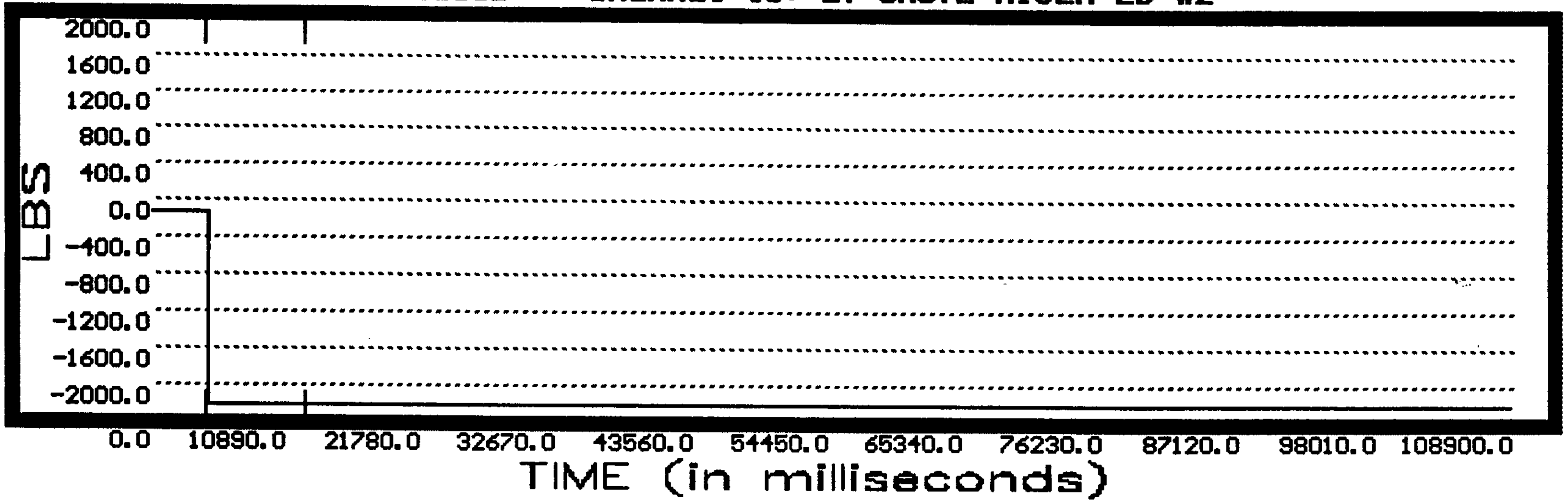

FL110005 -- Channel 36: LT LEG TORQUE POS
LBS
1000.0
800.0
600.0
400.0
200.0
-0.0
-200.0
-400.0
-600.0
-800.0
-1000.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)


FL110005 -- Channel 37: LT LEG TORQUE NEG
LBS
1000.0
800.0
600.0
400.0
200.0
-0.0
-200.0
-400.0
-600.0
-800.0
-1000.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

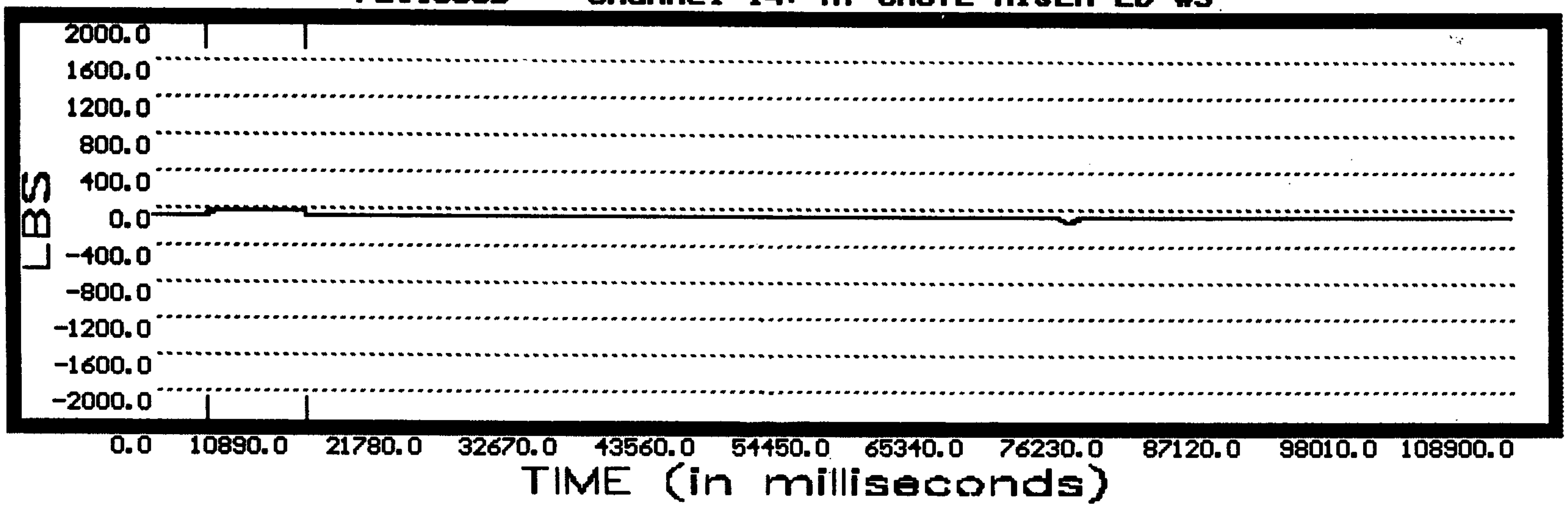

FL110005 -- Channel 38: RT LEG TORQUE POS
LBS
1000.0
800.0
600.0
400.0
200.0
-0.0
-200.0
-400.0
-600.0
-800.0
-1000.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)


FL110005 -- Channel 39: RT LEG TORQUE NEG
LBS
1000.0
800.0
600.0
400.0
200.0
-0.0
-200.0
-400.0
-600.0
-800.0
-1000.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)

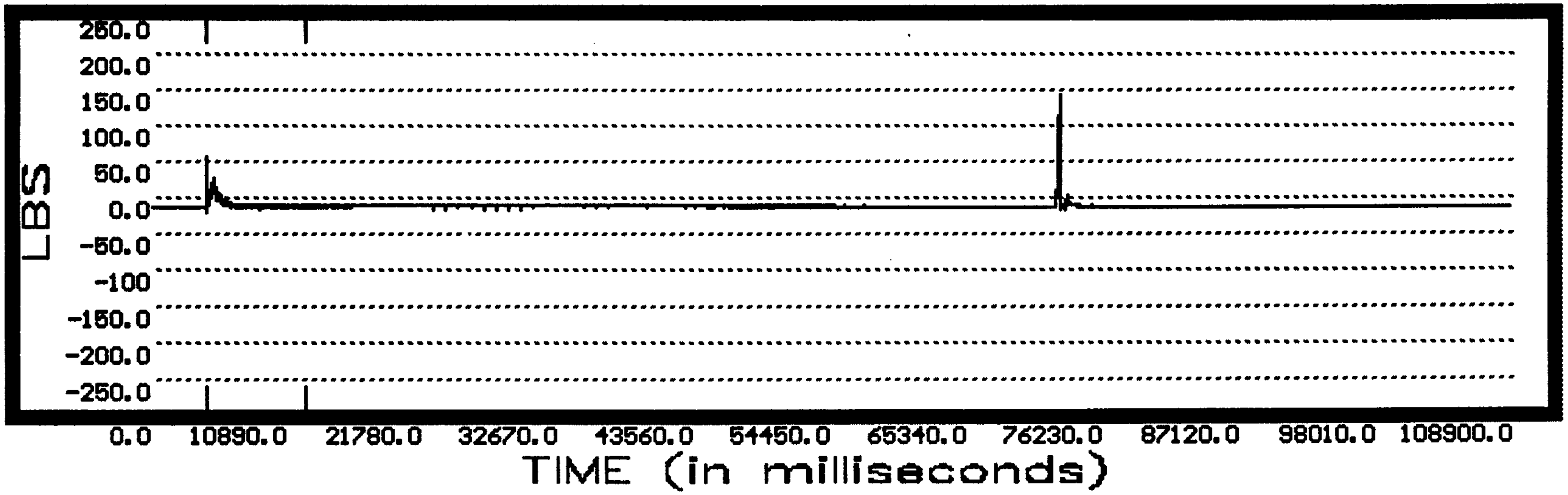
FL110005 -- Channel 13: LT CHUTE RISER LD #2



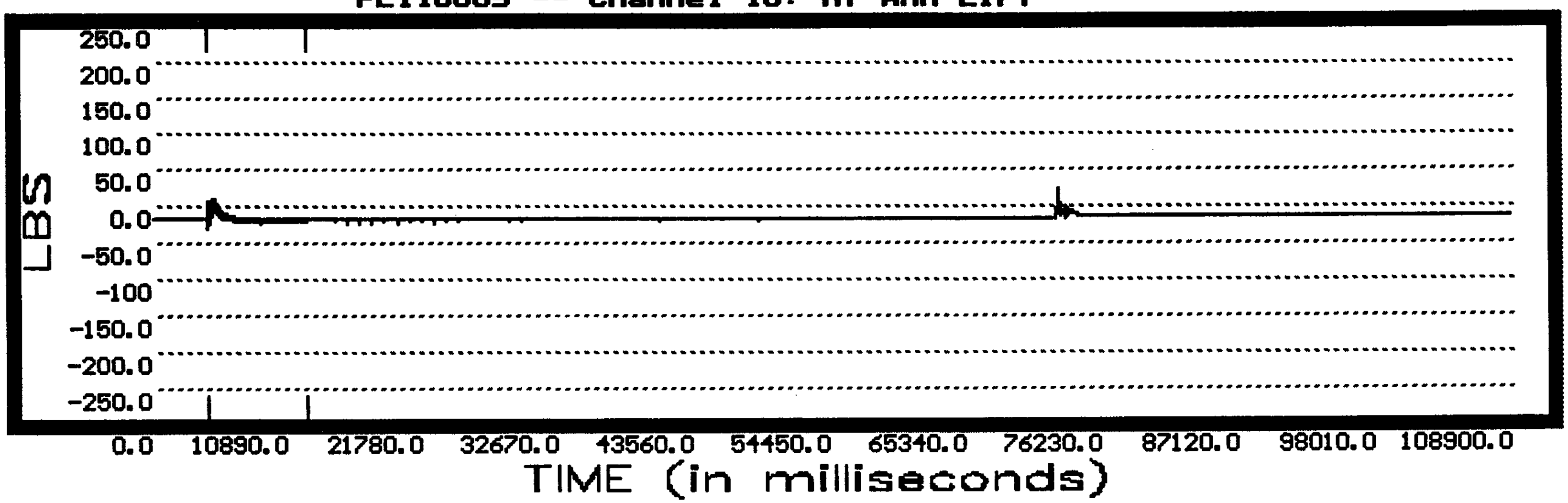
FL110005 -- Channel 14: RT CHUTE RISER LD #3



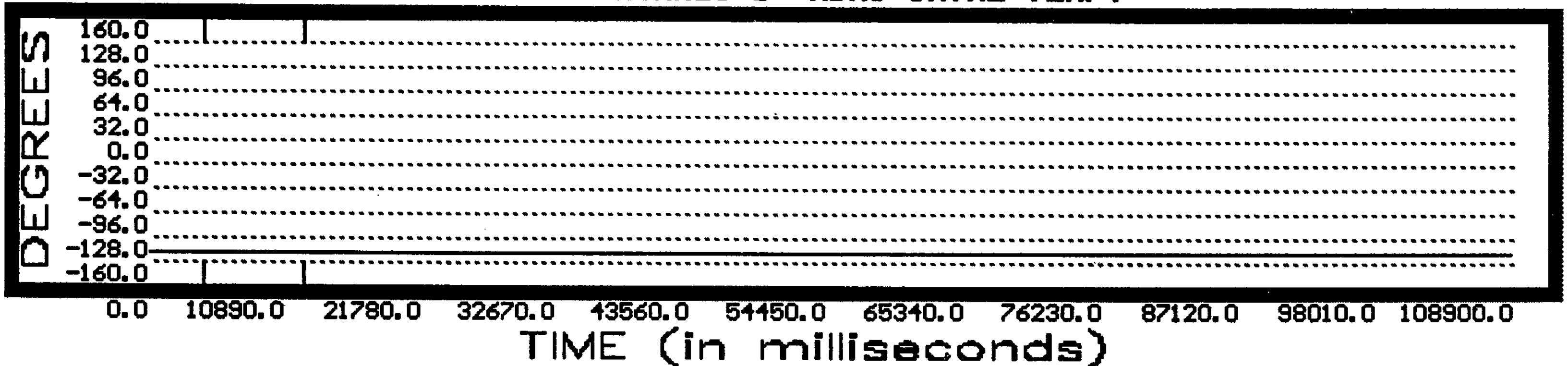
FL110005 -- Channel 15: LT ARM LIFT



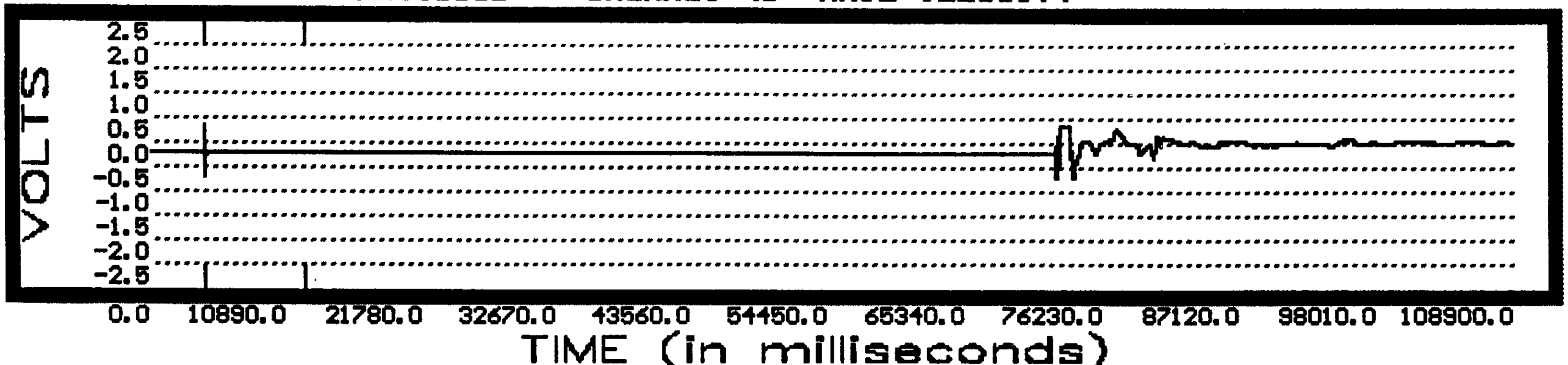
FL110005 -- Channel 16: RT ARM LIFT



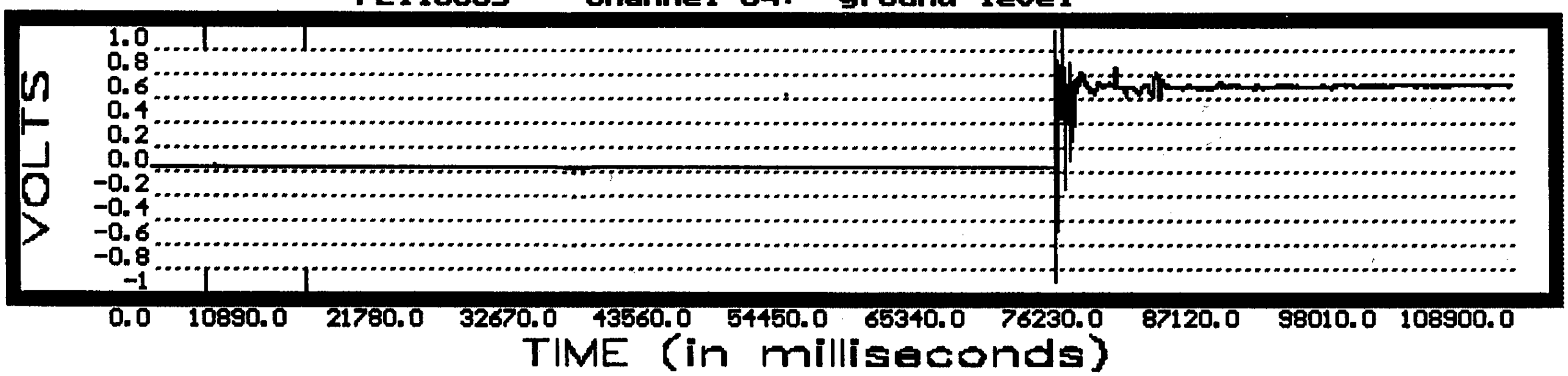
FL110005 -- Channel 8: ADAS INTRL TEMP.

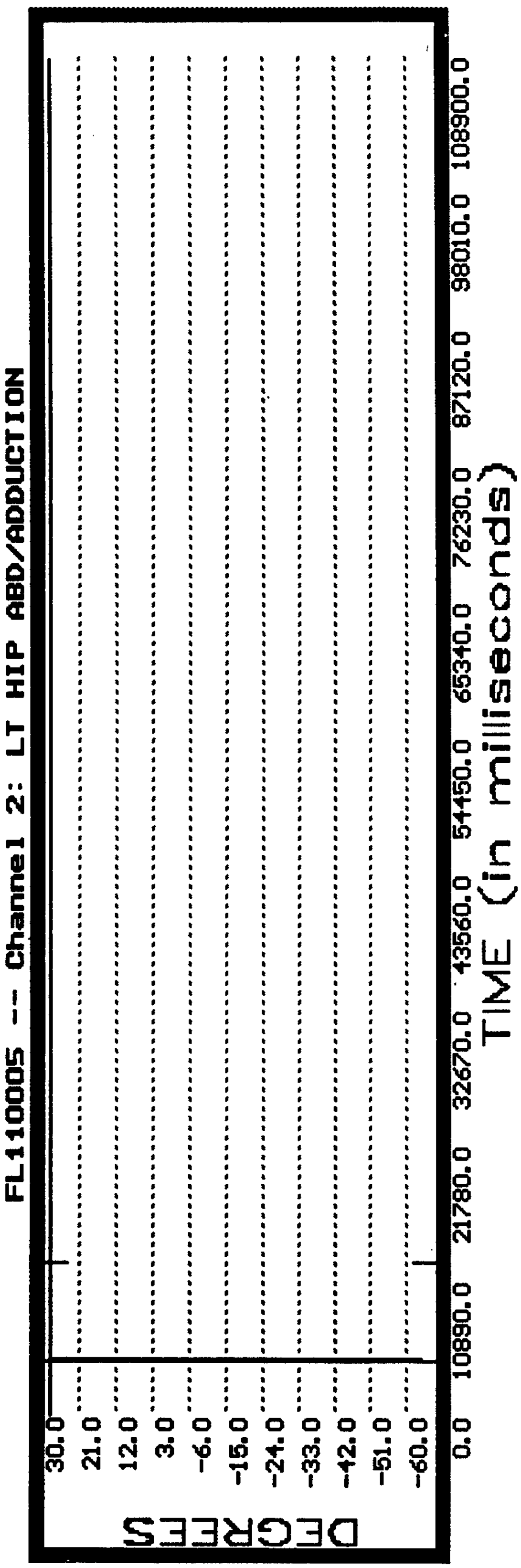


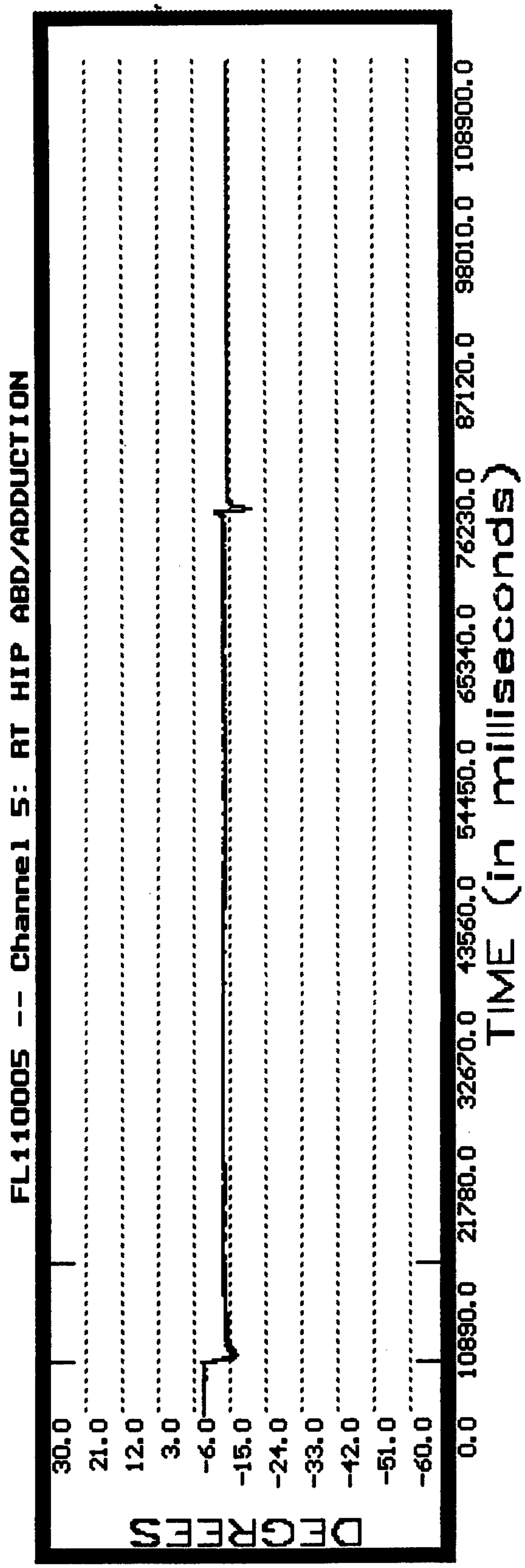
FL110005 -- Channel 40: RAIL VELOCITY

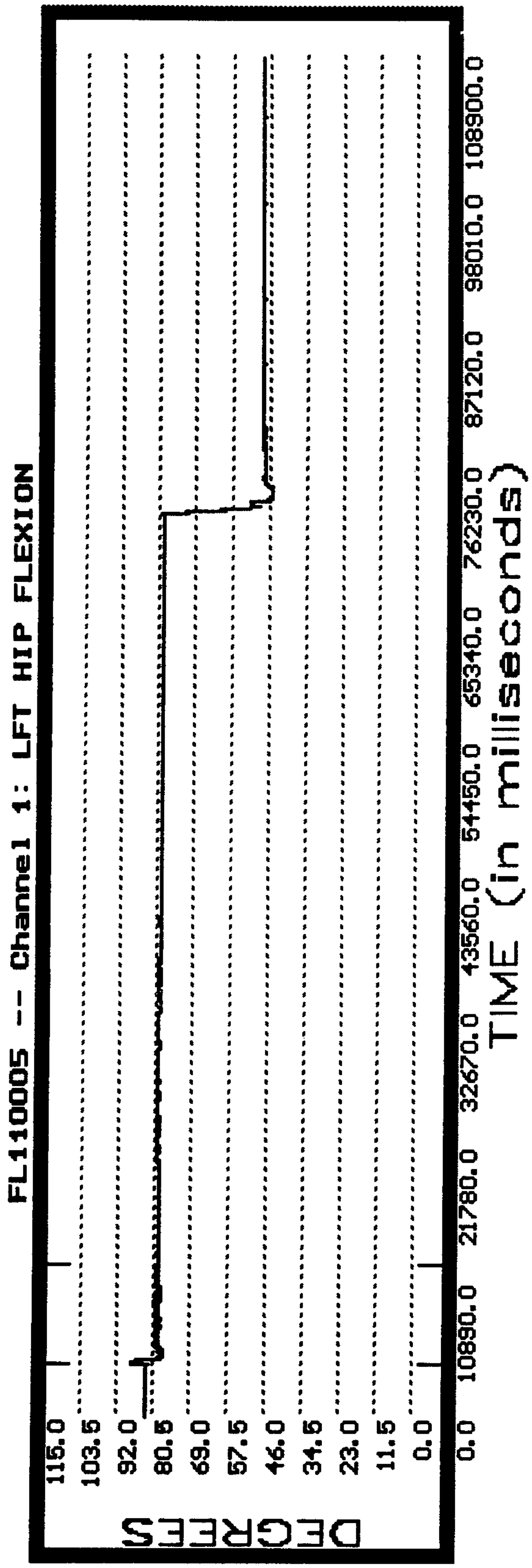


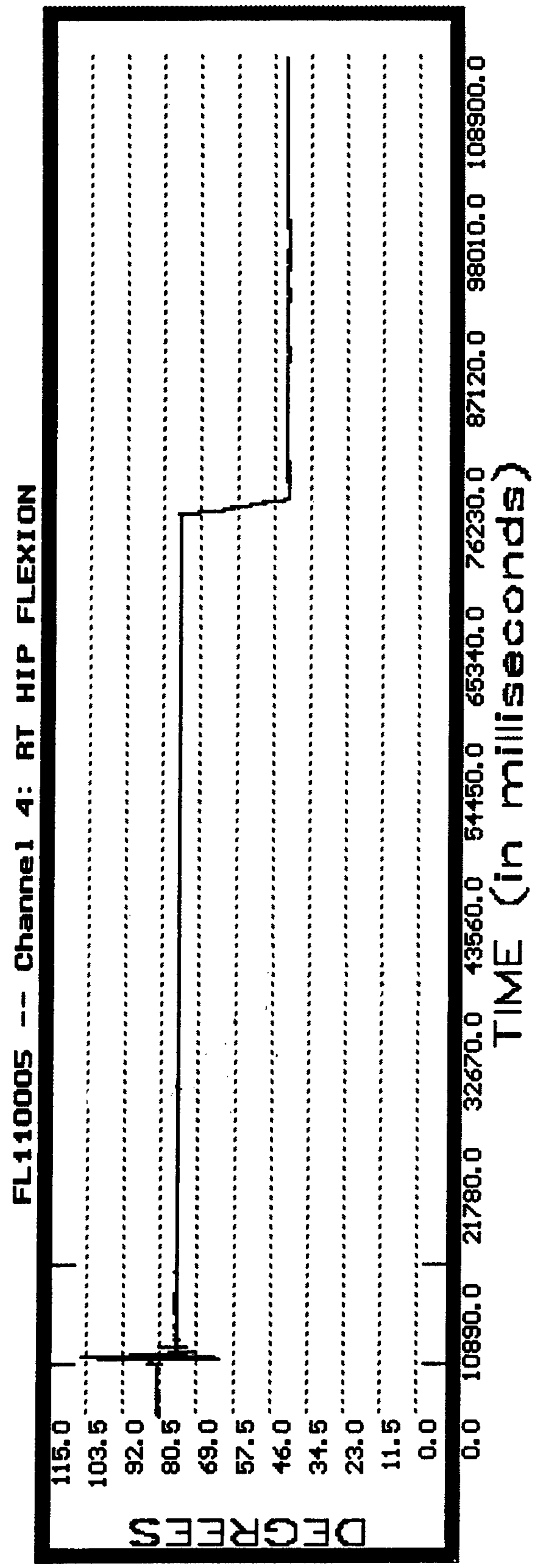
FL110005 -- Channel 64: ground level

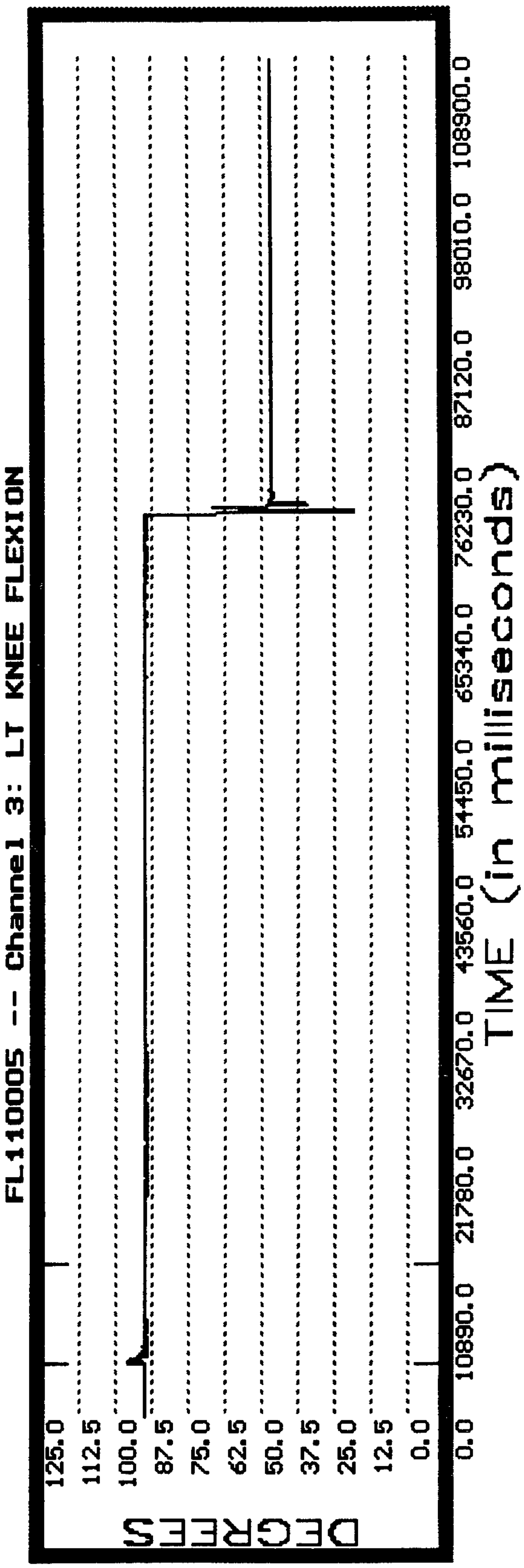


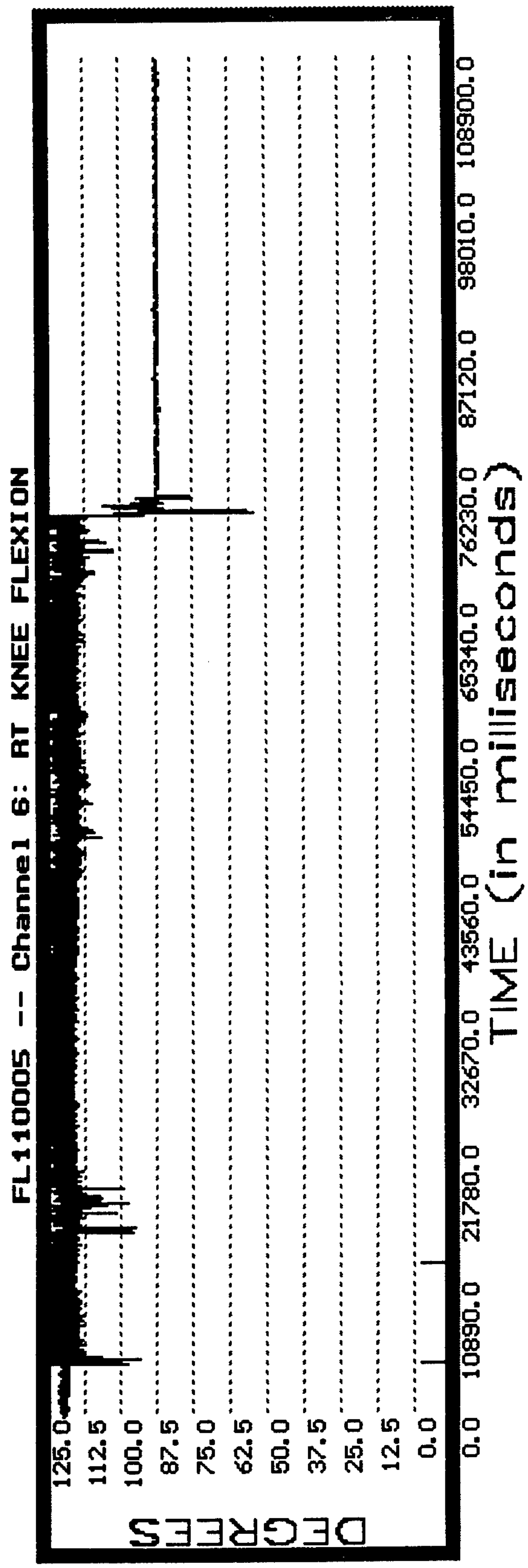

FL110005 -- Channel 2: LT HIP ABD/ADDUCTION
DEGREES
30.0
21.0
12.0
3.0
-6.0
-15.0
-24.0
-33.0
-42.0
-51.0
-60.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)


FL110005 -- Channel 5: RT HIP ABD/ADDUCTION
DEGREES
30.0
21.0
12.0
3.0
-6.0
-15.0
-24.0
-33.0
-42.0
-51.0
-60.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)

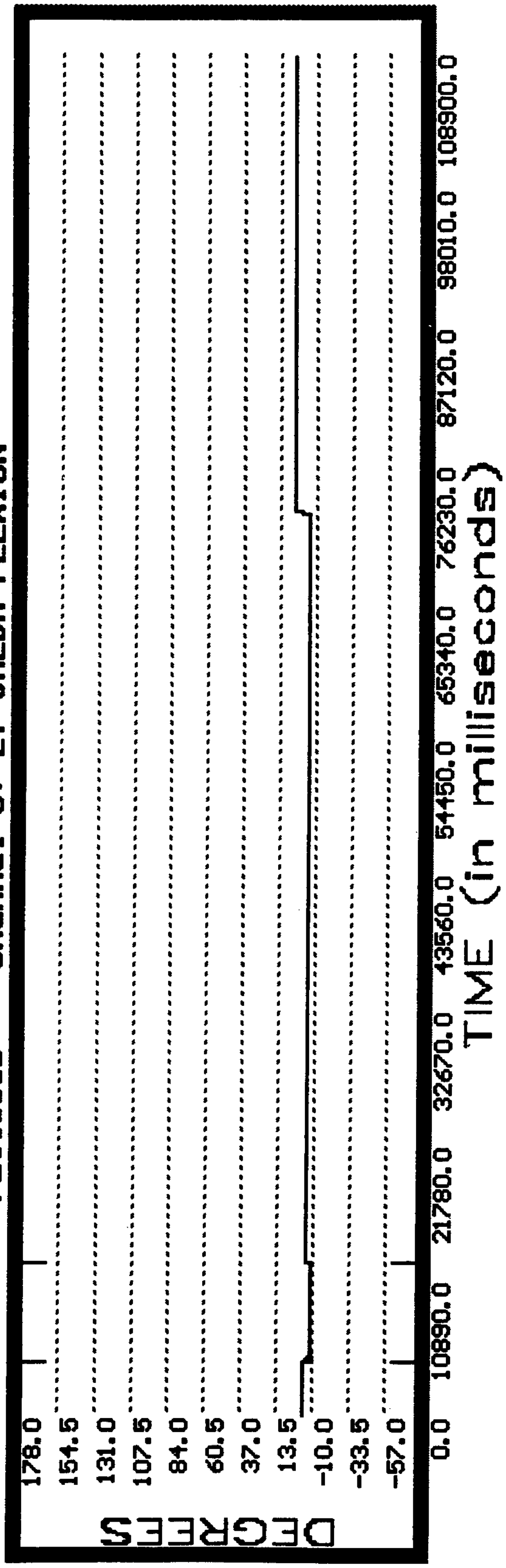

FL110005 -- Channel 1: LFT HIP FLEXION
DEGREES
115.0
103.5
92.0
80.5
69.0
57.5
46.0
34.5
23.0
11.5
0.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)


FL110005 -- Channel 4: RT HIP FLEXION
DEGREES
115.0
103.5
92.0
80.5
69.0
57.5
46.0
34.5
23.0
11.5
0.0
0.0
10890.0
21780.0
32670.0
43560.0
54450.0
65340.0
76230.0
87120.0
98010.0
108900.0
TIME (in milliseconds)

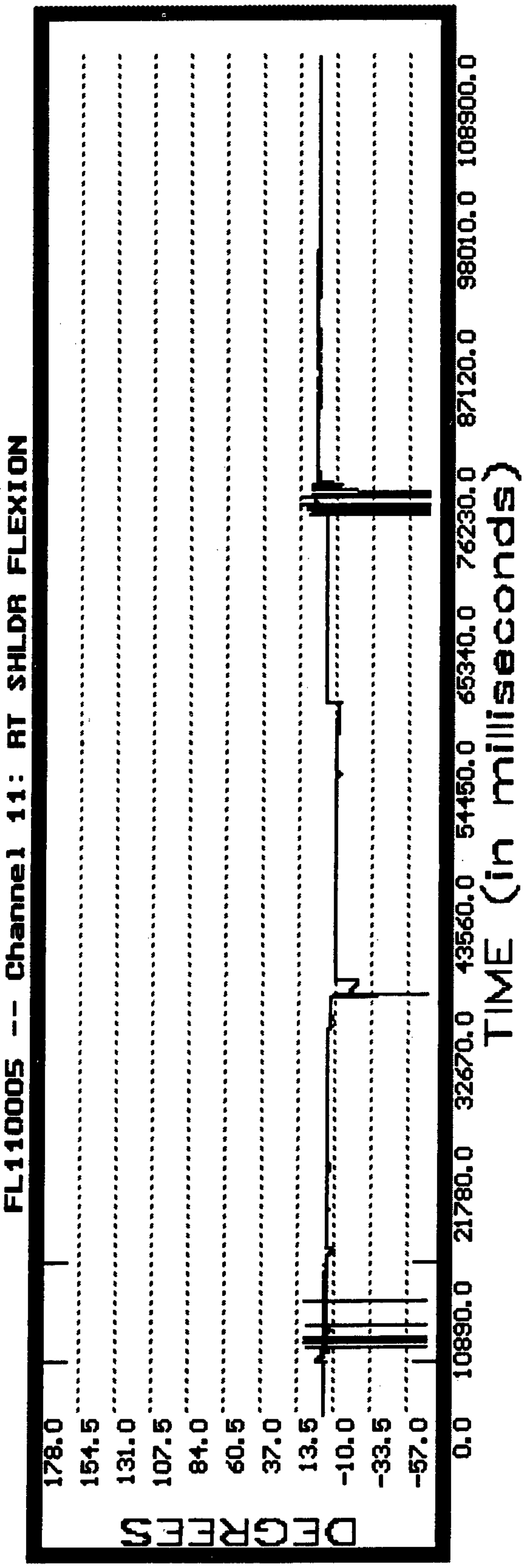

FL110005 -- Channel 3: LT KNEE FLEXION
DEGREES
125.0
112.5
100.0
87.5
75.0
62.5
50.0
37.5
25.0
12.5
0.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

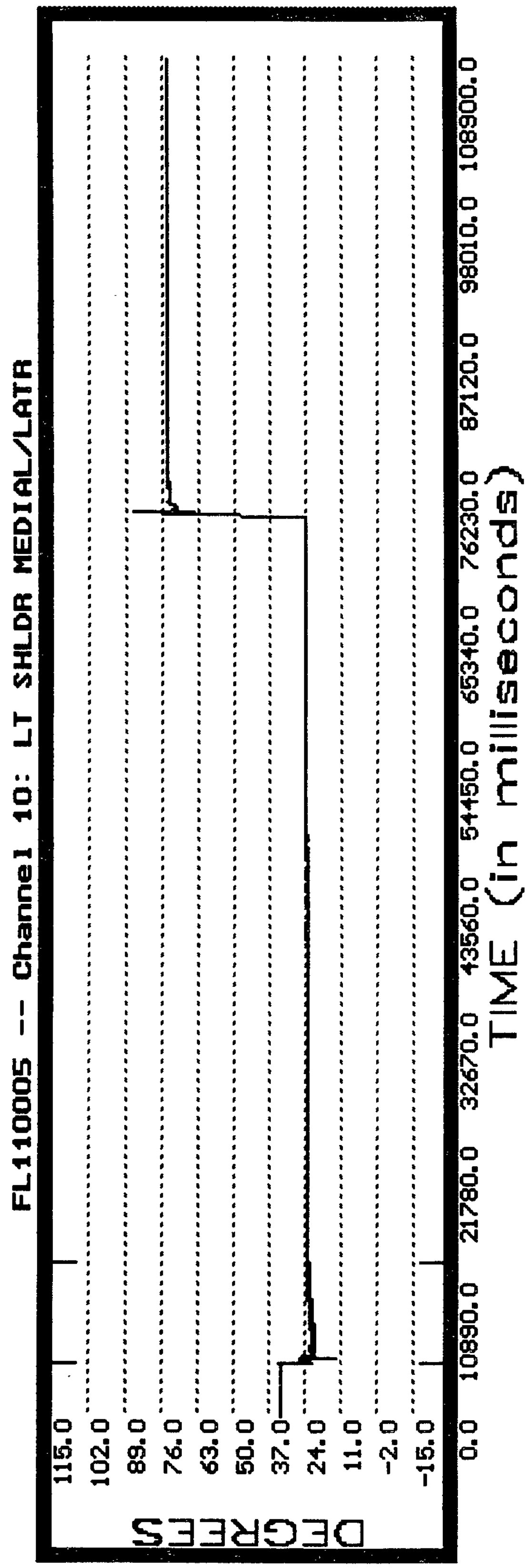

FL110005 -- Channel 6: RT KNEE FLEXION
DEGREES
125.0
112.5
100.0
87.5
75.0
62.5
50.0
37.5
25.0
12.5
0.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

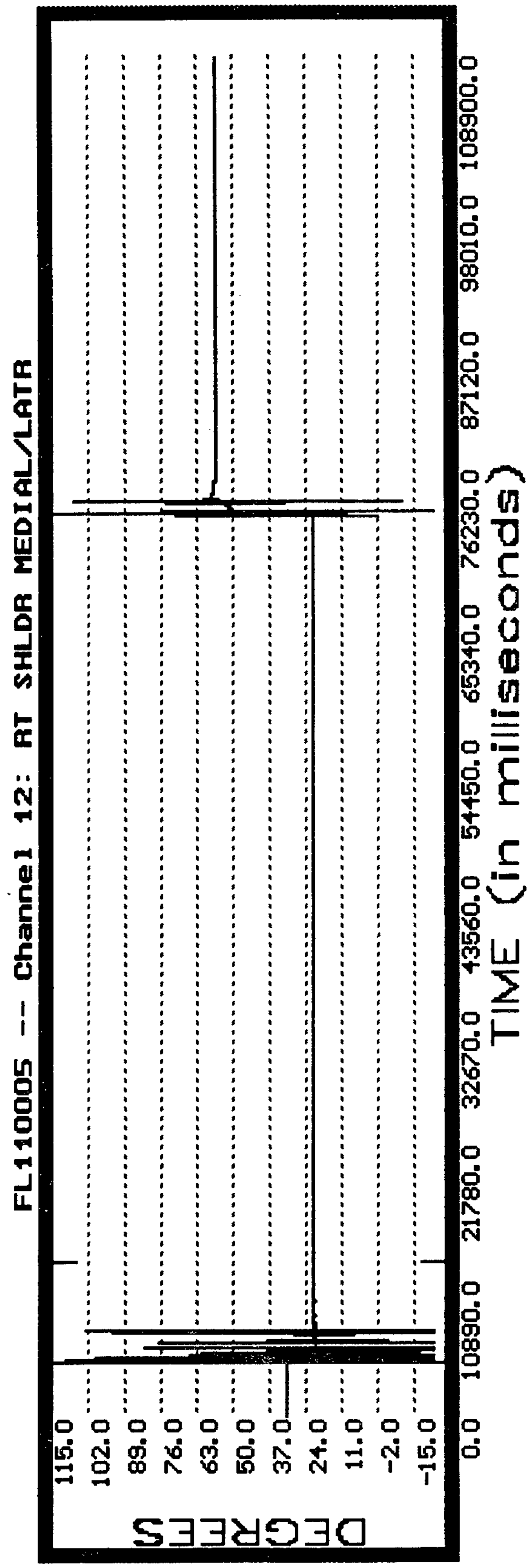
FL110005 -- Channel 9: LT SHLDR FLEXION



FL110005 -- Channel 11: RT SHLDR FLEXION




FL110005 -- Channel 10: LT SHLDR MEDIAL/LATR
DEGREES
115.0
102.0
89.0
76.0
63.0
50.0
37.0
24.0
11.0
-2.0
-15.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)


FL110005 -- Channel 12: RT SHLDR MEDIAL/LATR
DEGREES
115.0
102.0
89.0
76.0
63.0
50.0
37.0
24.0
11.0
-2.0
-15.0
0.0 10890.0 21780.0 32670.0 43560.0 54450.0 65340.0 76230.0 87120.0 98010.0 108900.0
TIME (in milliseconds)

Appendix G

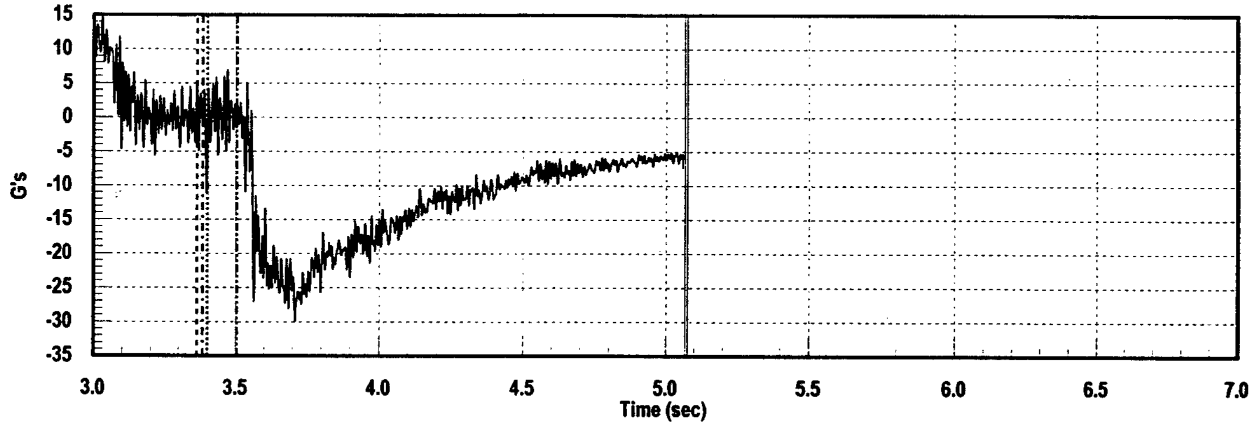
Rocket Sled Processed Data

SL1400, 730 KEAS
Processed Data

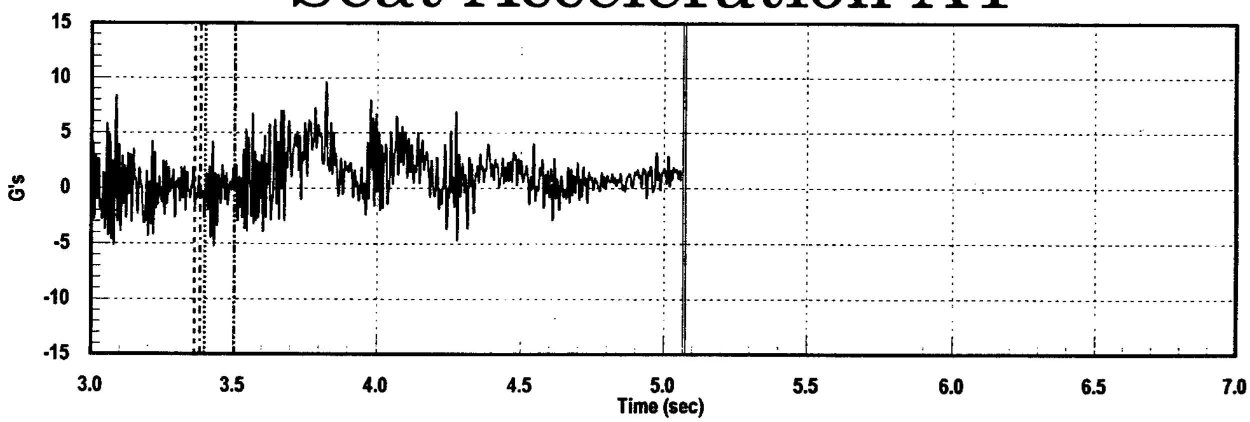
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

SL1400, 730 KEAS

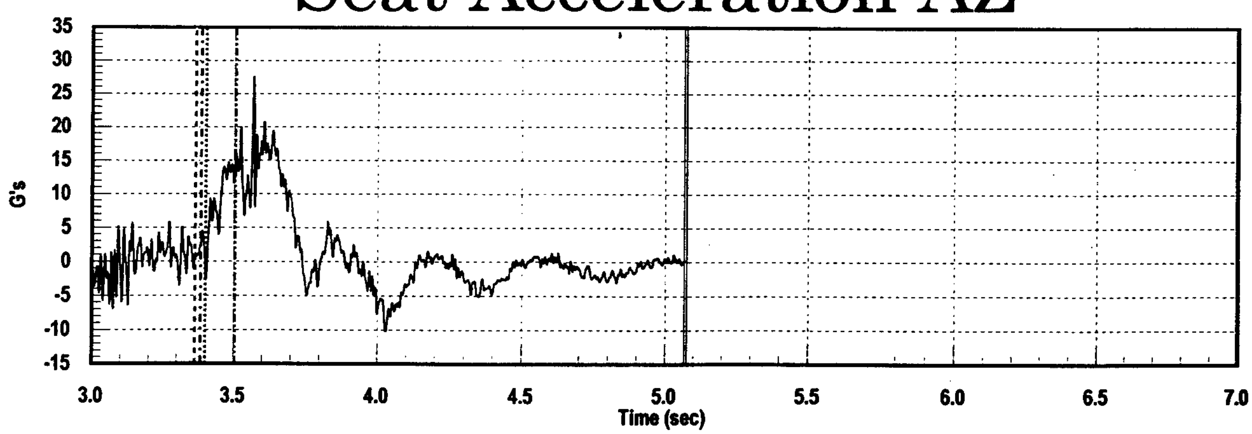
Seat Acceleration AX



Seat Acceleration AY



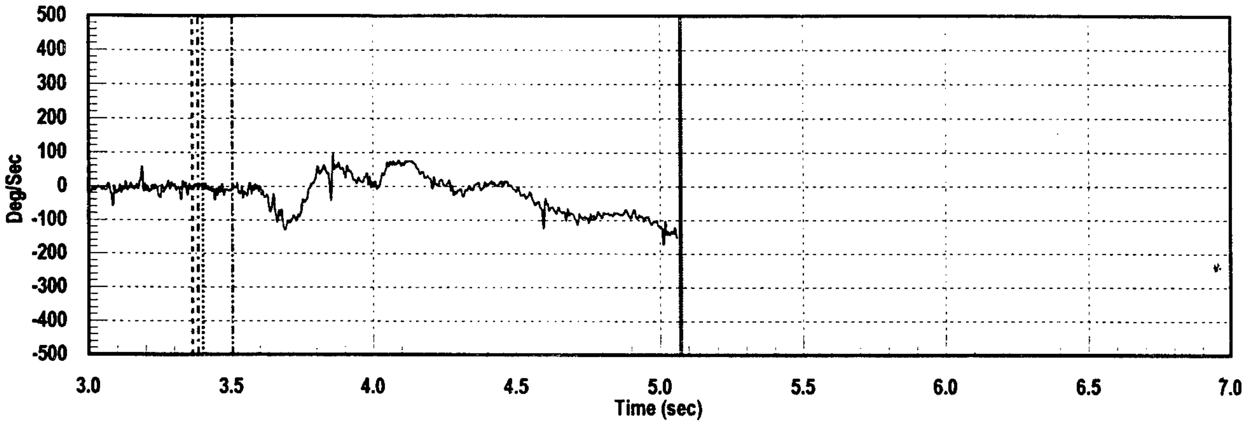
Seat Acceleration AZ



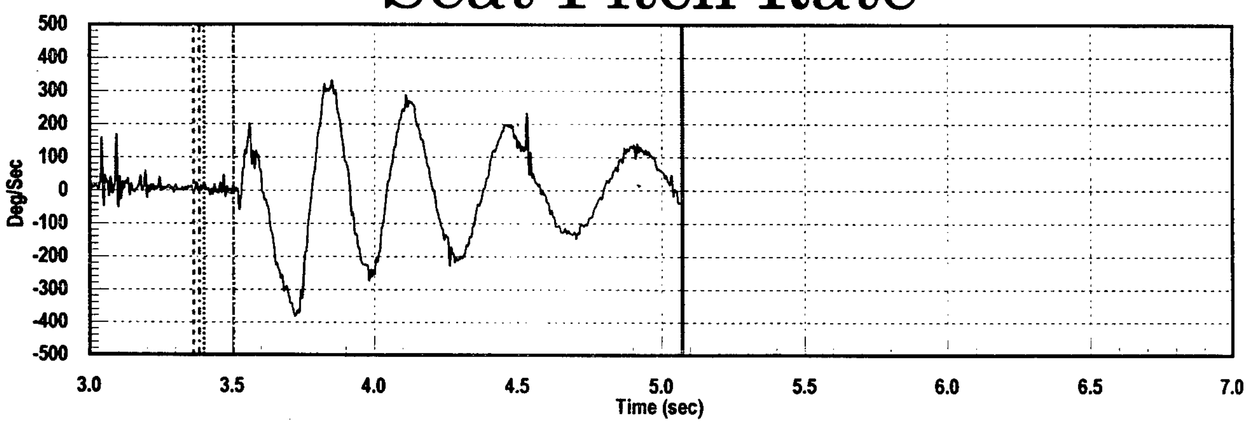
A-1

SL1400, 730 KEAS

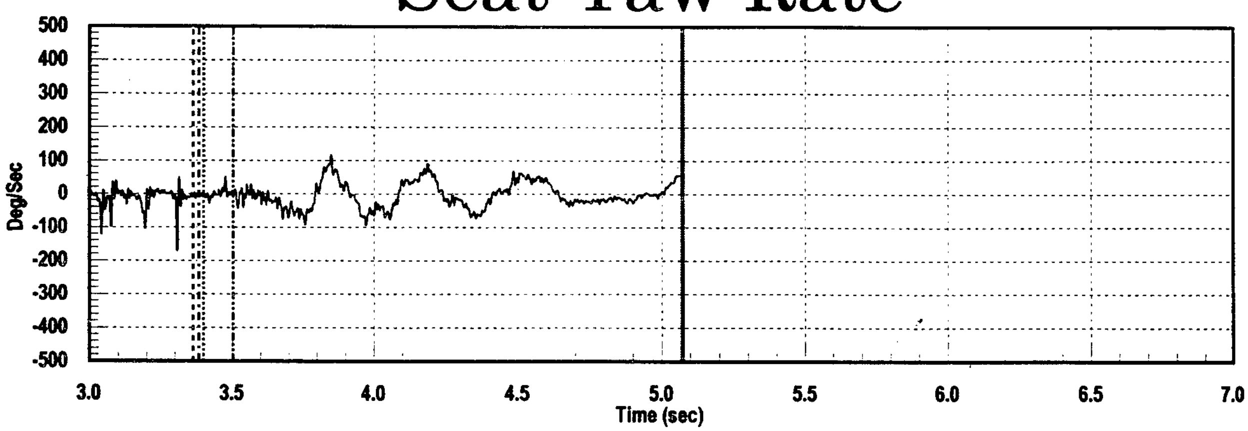
Seat Roll Rate



Seat Pitch Rate



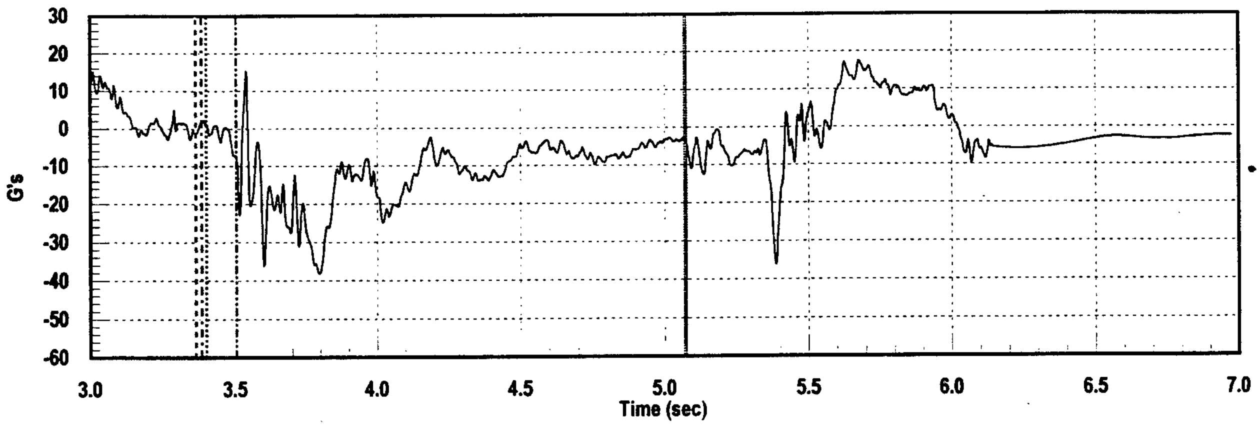
Seat Yaw Rate



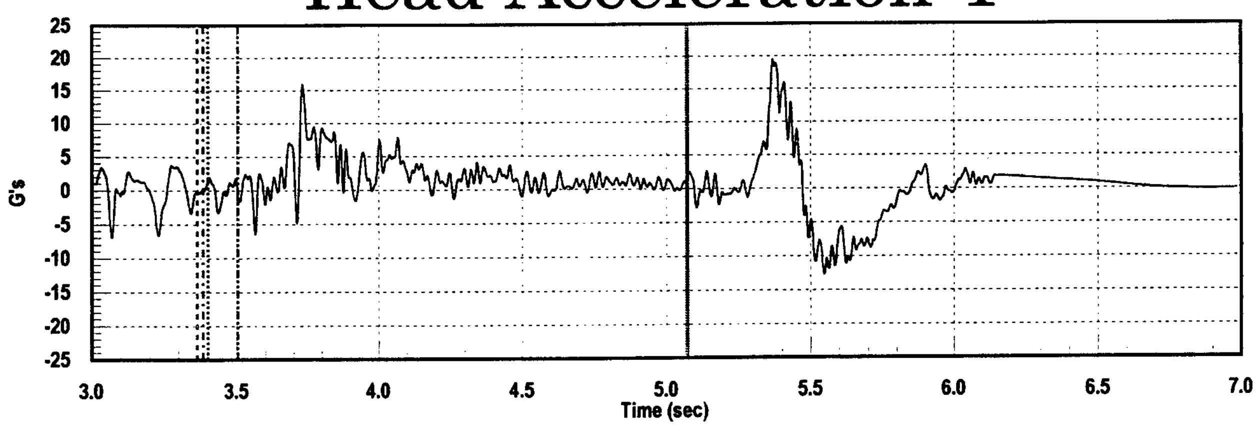
A-5

SL1400, 730 KEAS

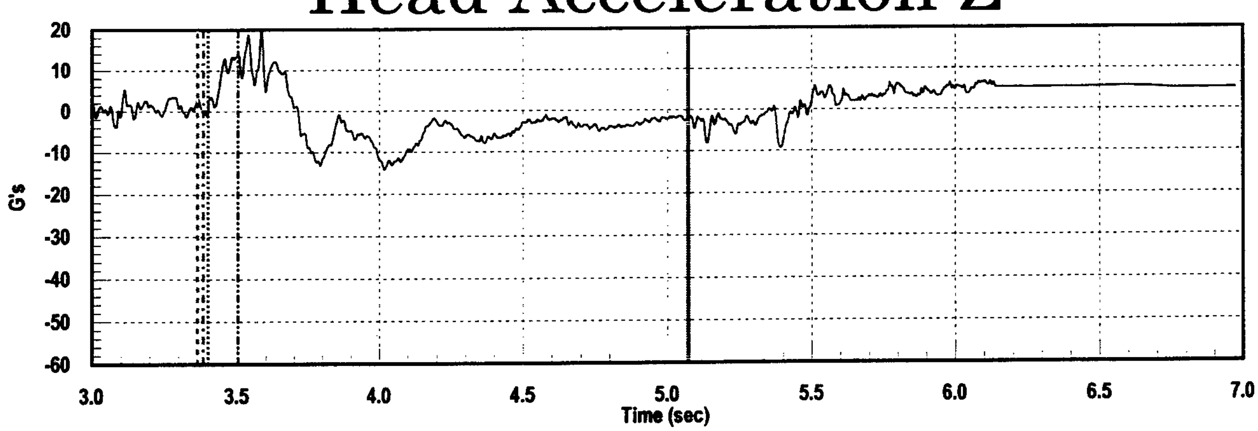
Head Acceleration X



Head Acceleration Y



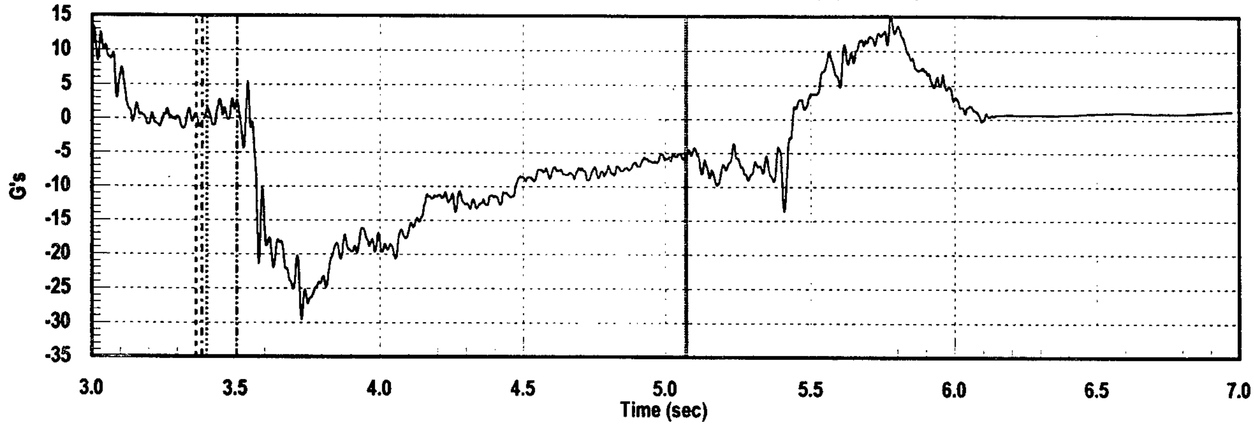
Head Acceleration Z



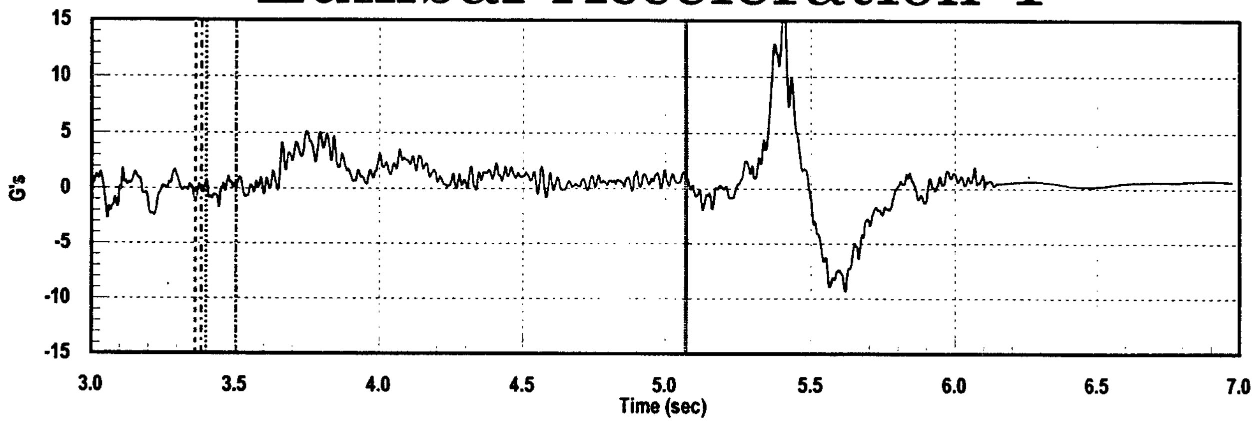
A-6

SL1400, 730 KEAS

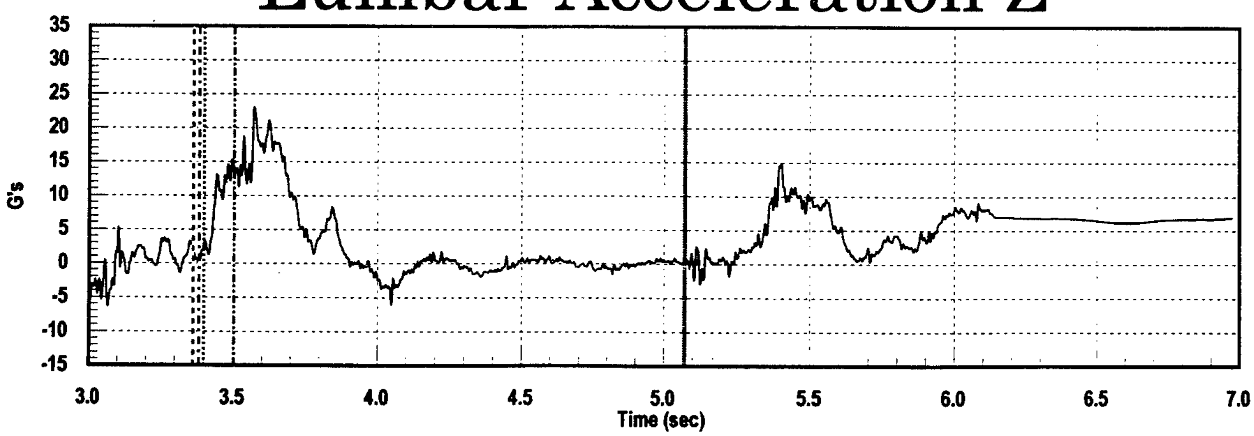
Lumbar Acceleration X



Lumbar Acceleration Y



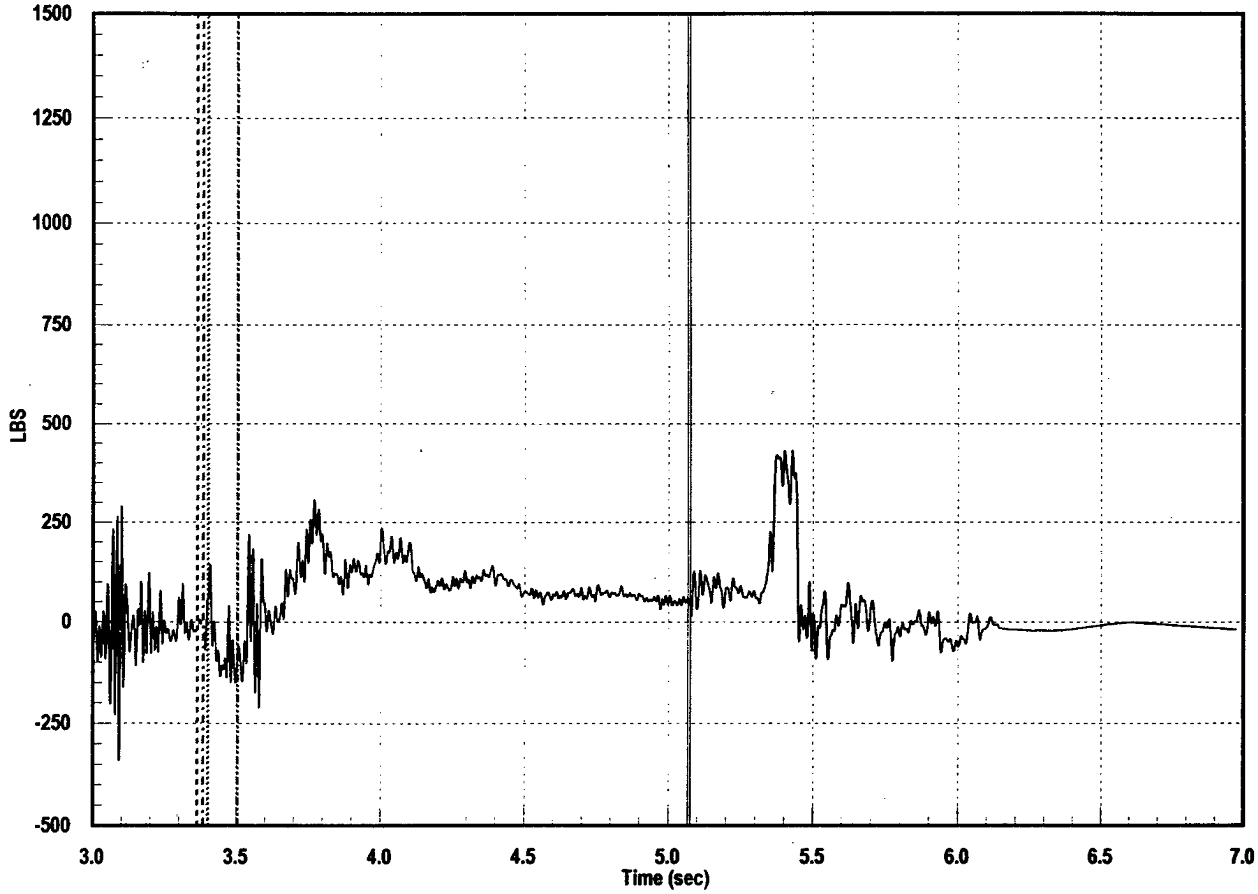
Lumbar Acceleration Z



A-8

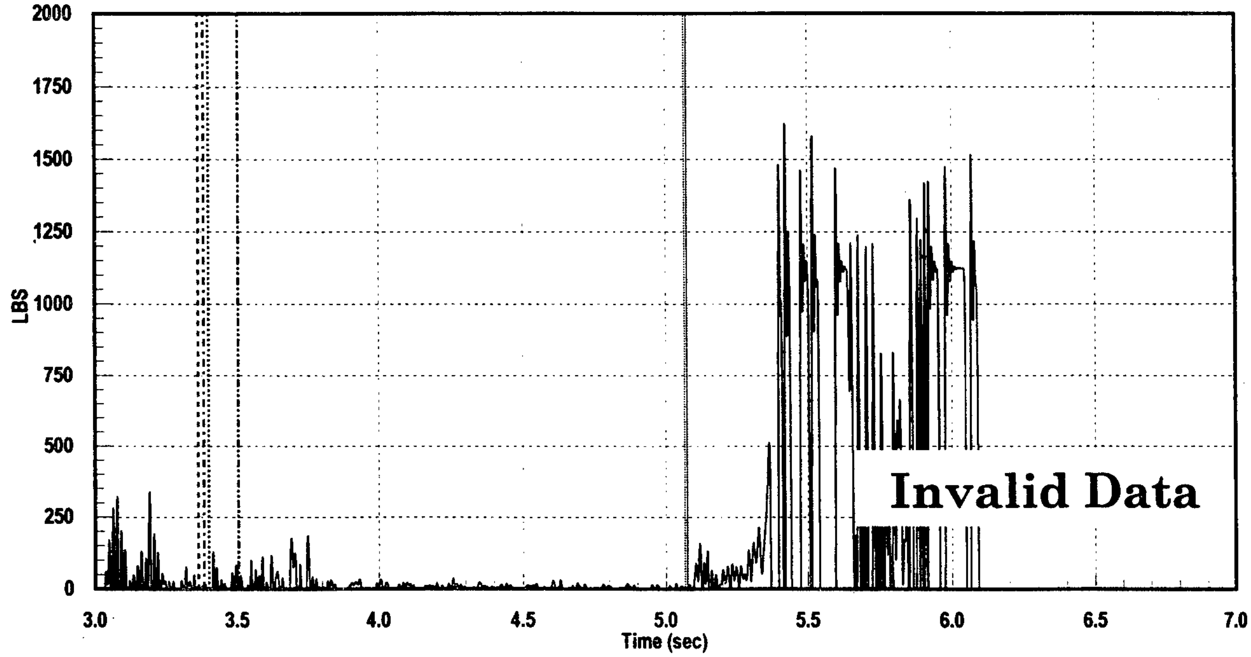
SL1400, 730 KEAS

Head/Neck Force Z

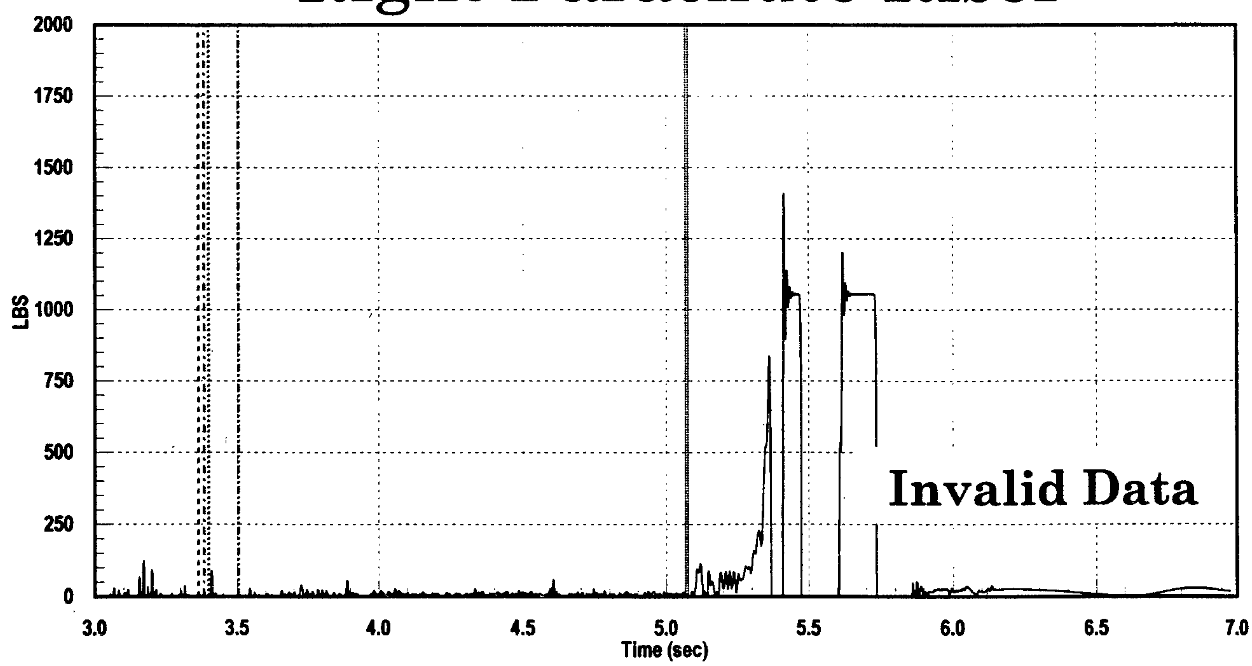


SL1400, 730 KEAS

Left Parachute Riser



Right Parachute Riser



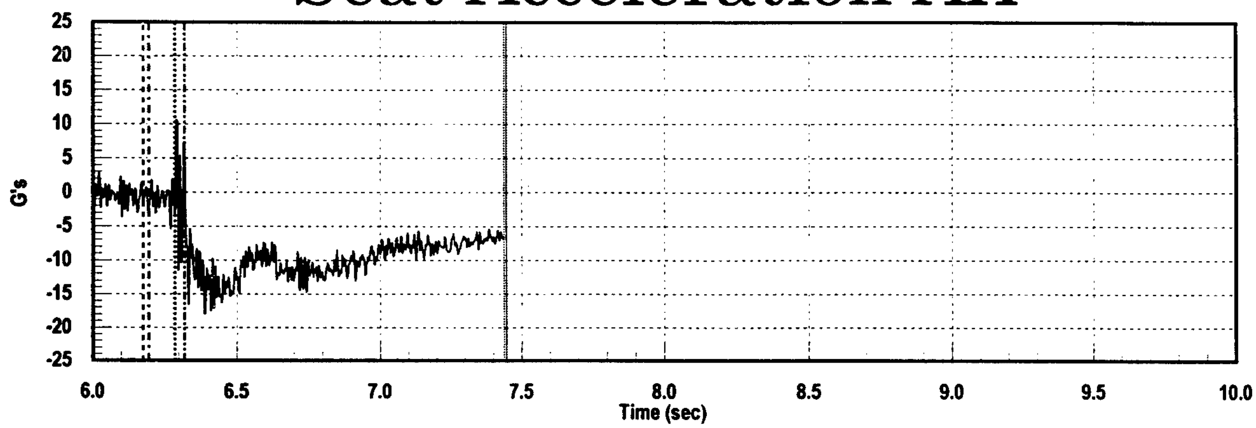
A-17

SL1050, 532 KEAS
Processed Data

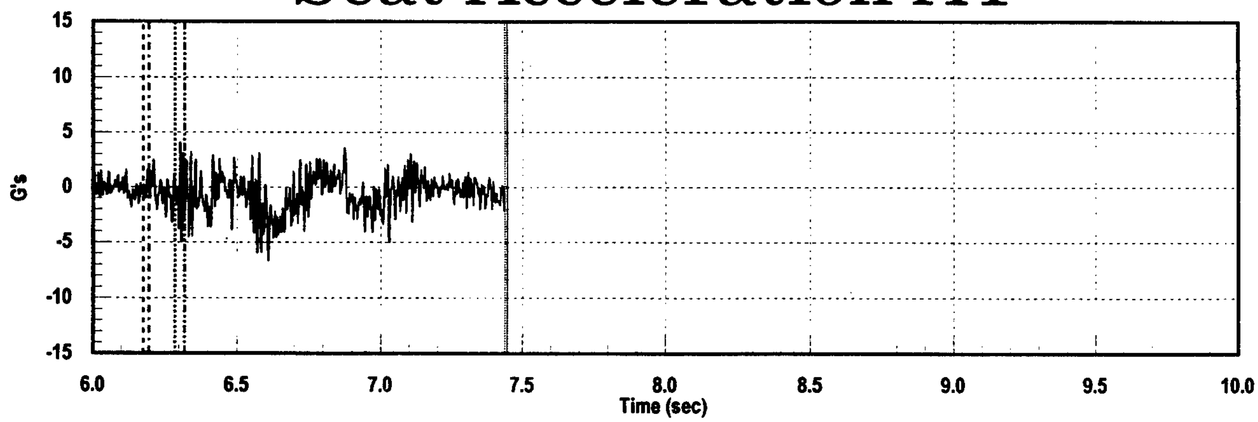
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

SL1050, 532 KEAS

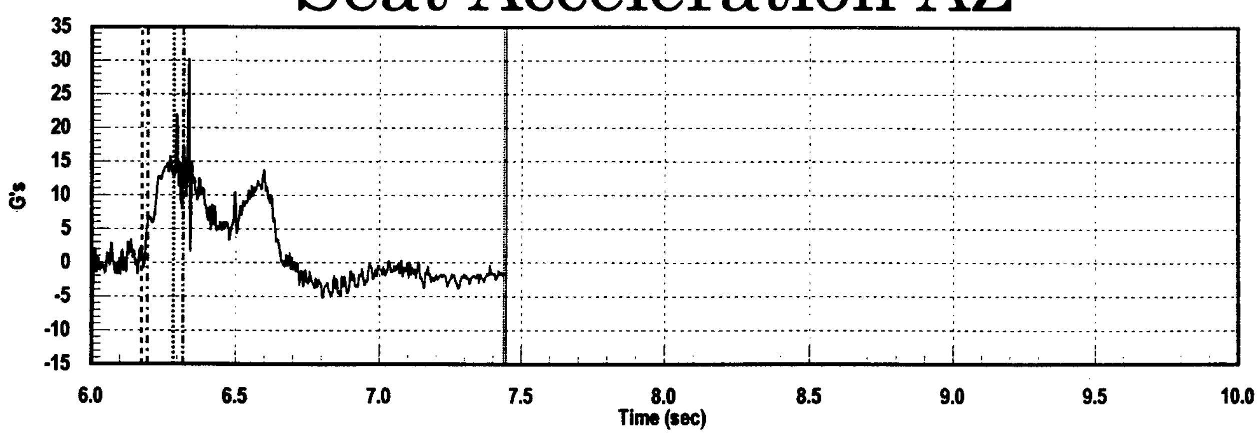
Seat Acceleration AX



Seat Acceleration AY

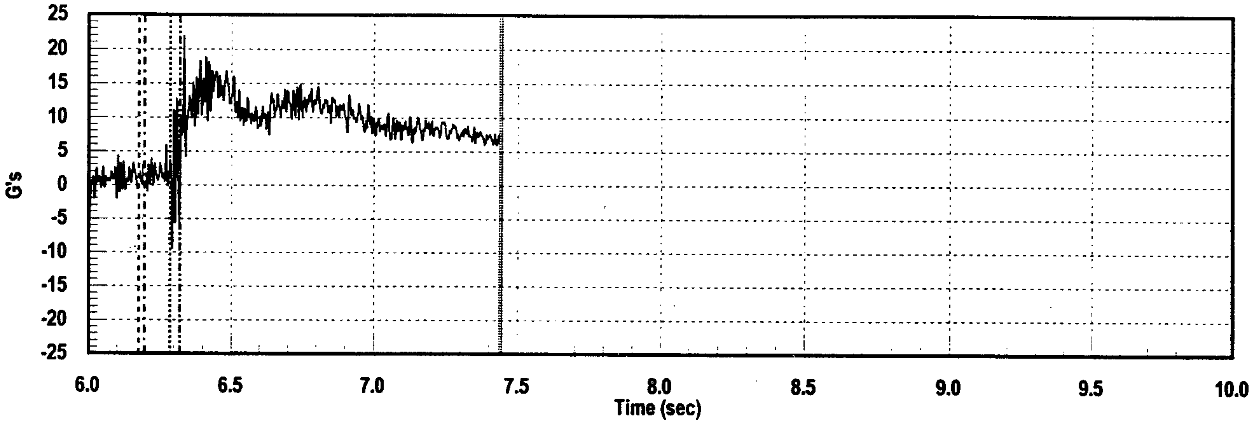


Seat Acceleration AZ

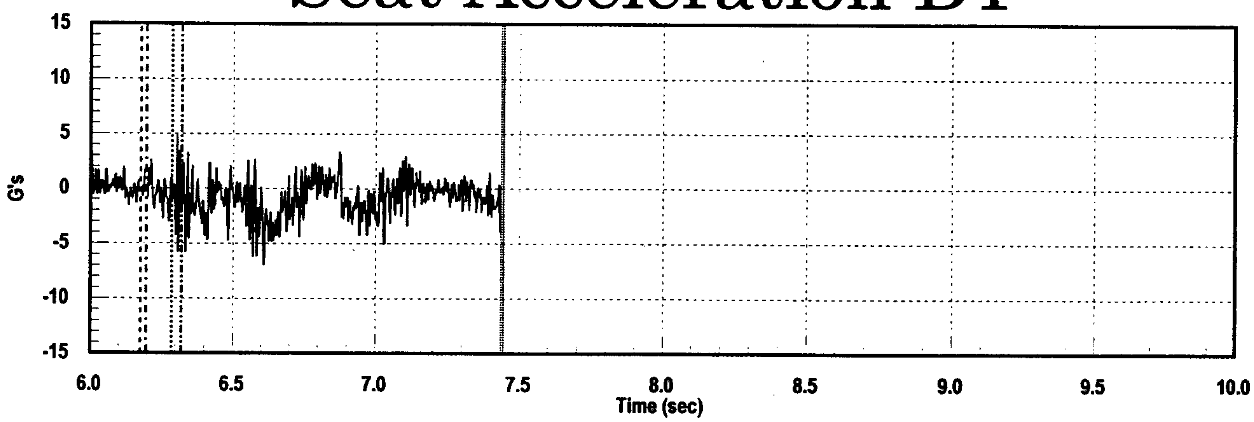


SL1050, 532 KEAS

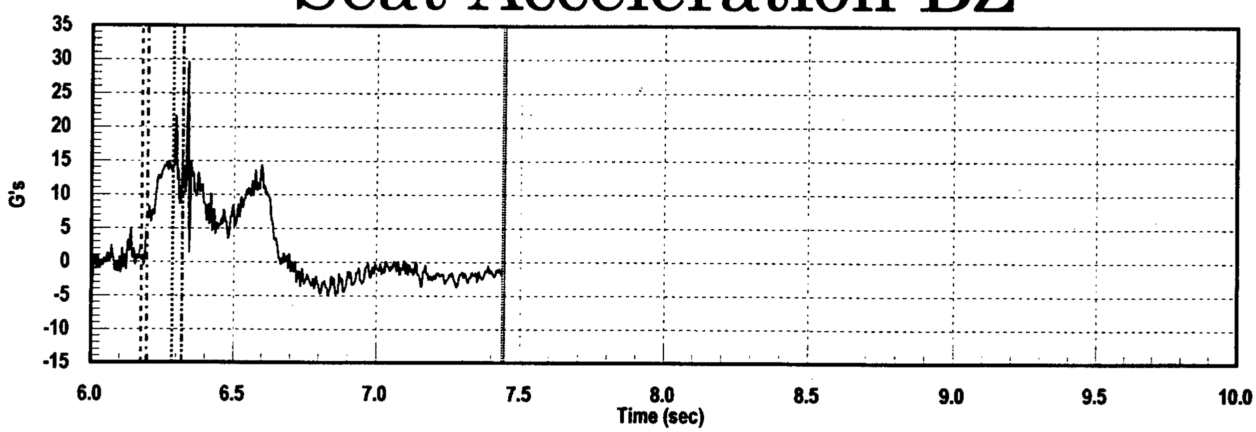
Seat Acceleration BX



Seat Acceleration BY



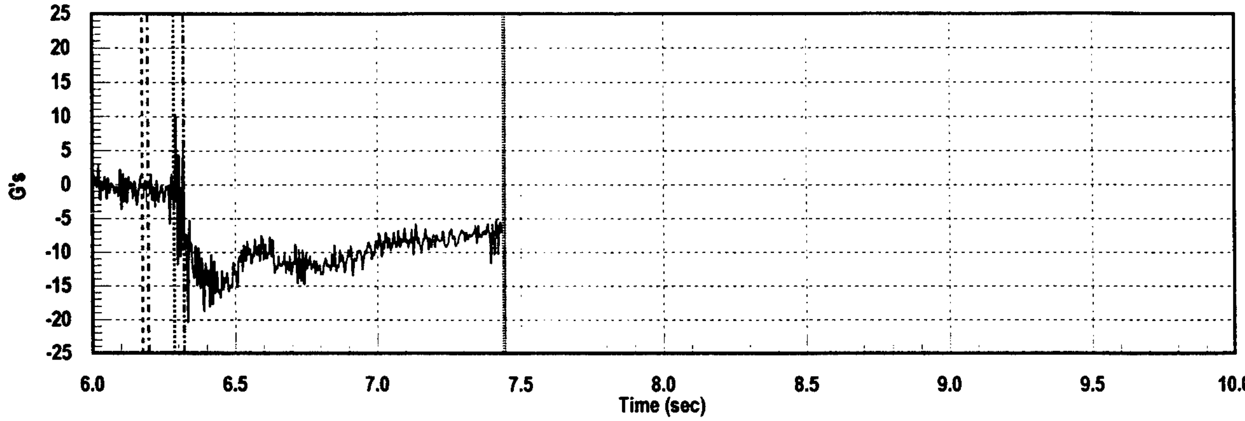
Seat Acceleration BZ



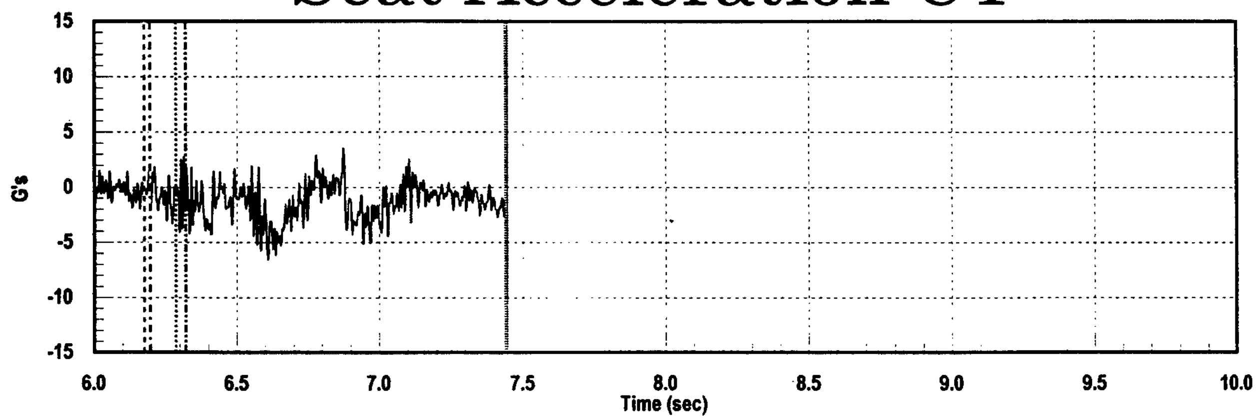
A-2

SL1050, 532 KEAS

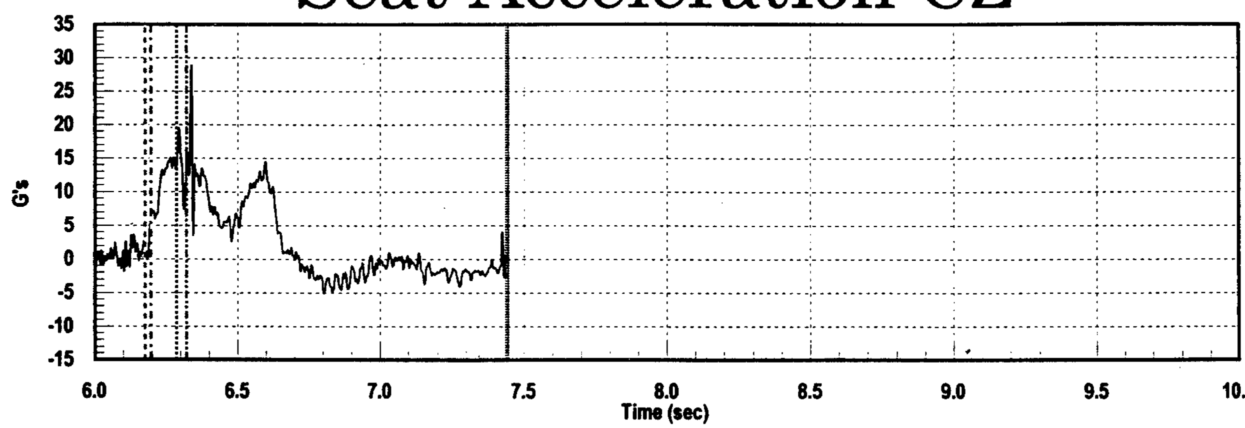
Seat Acceleration CX



Seat Acceleration CY



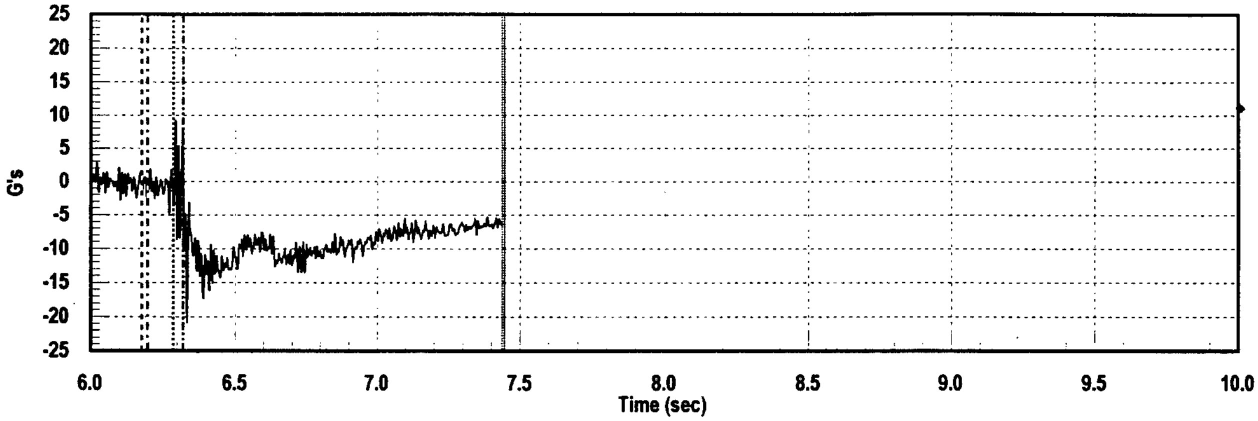
Seat Acceleration CZ



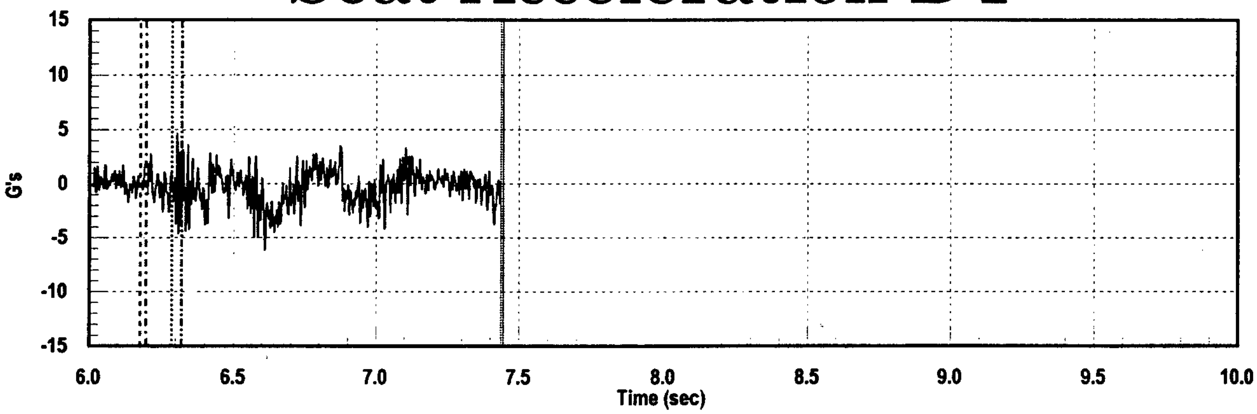
A-3

SL1050, 532 KEAS

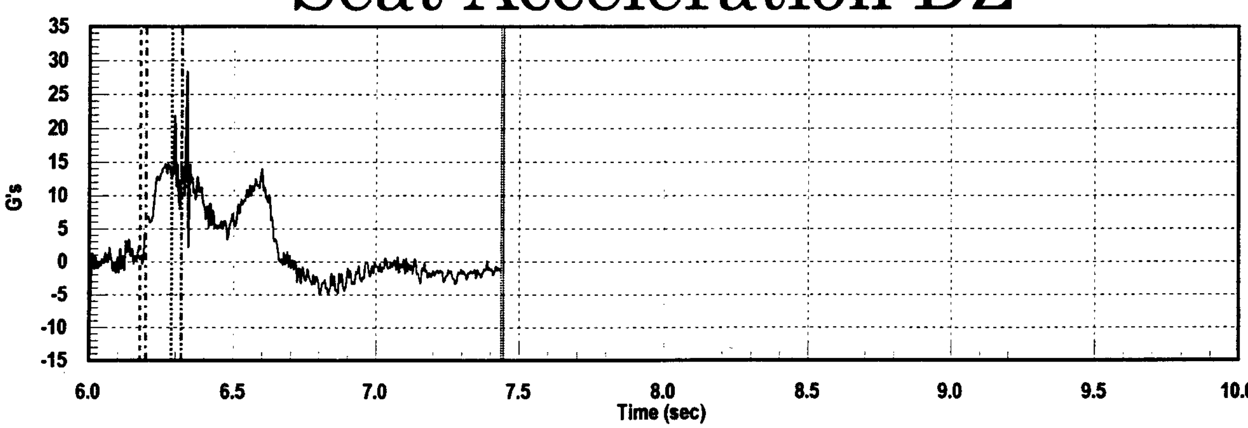
Seat Acceleration DX



Seat Acceleration DY

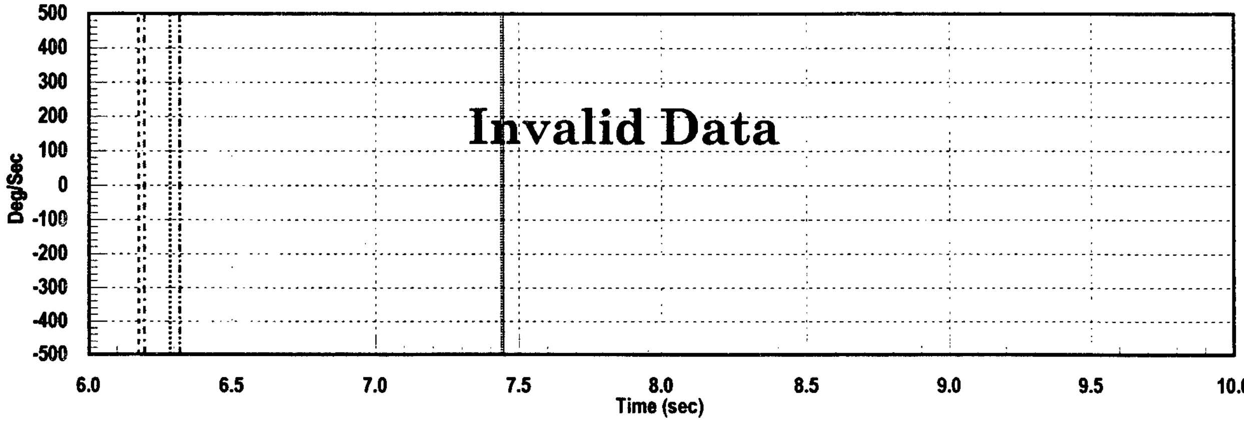


Seat Acceleration DZ

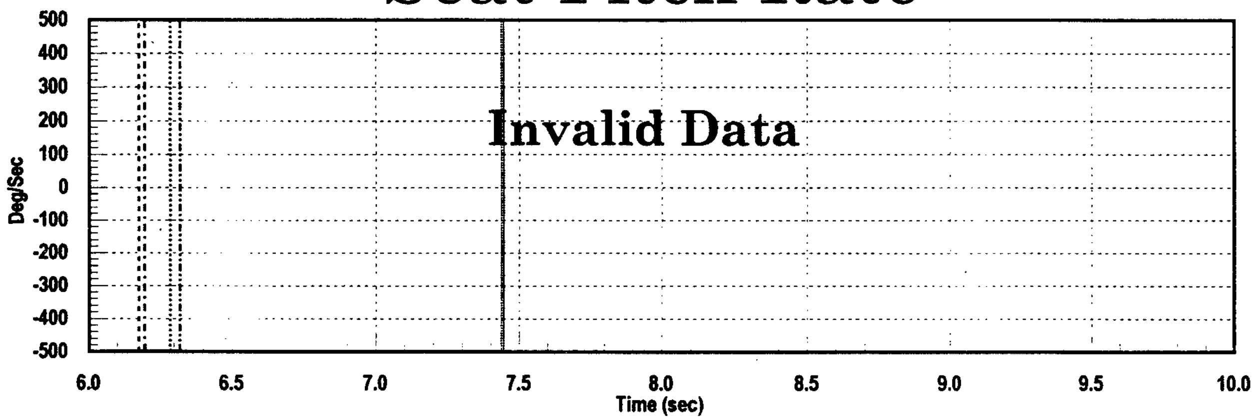


SL1050, 532 KEAS

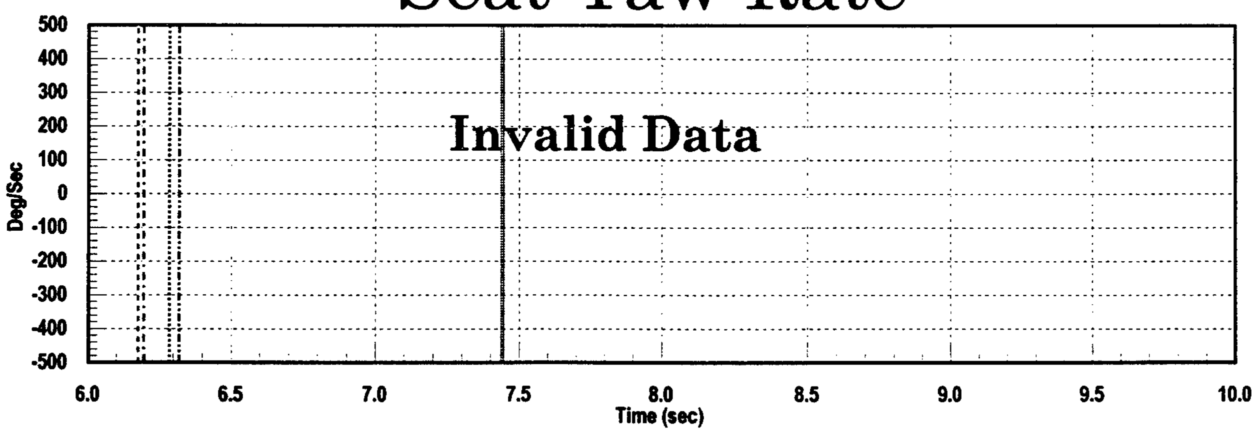
Seat Roll Rate



Seat Pitch Rate



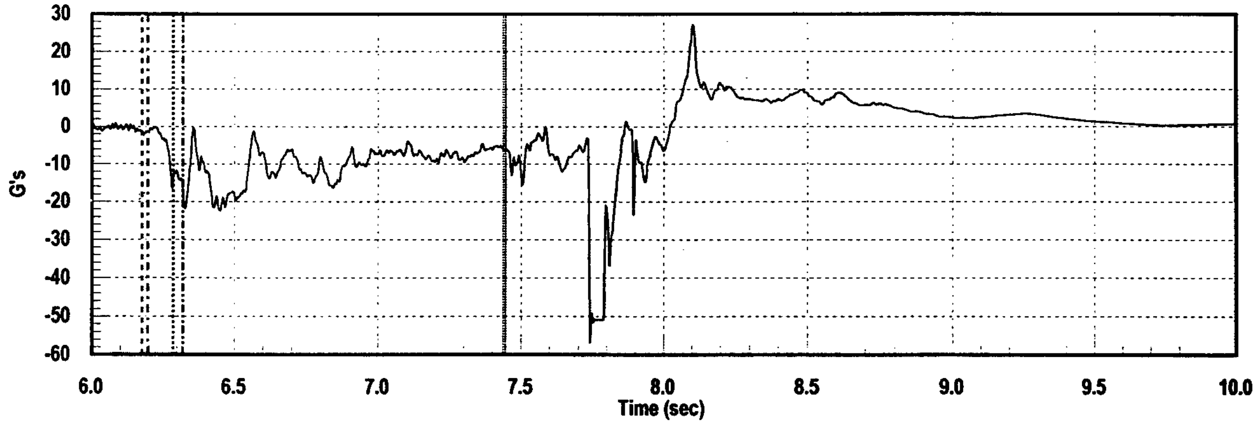
Seat Yaw Rate



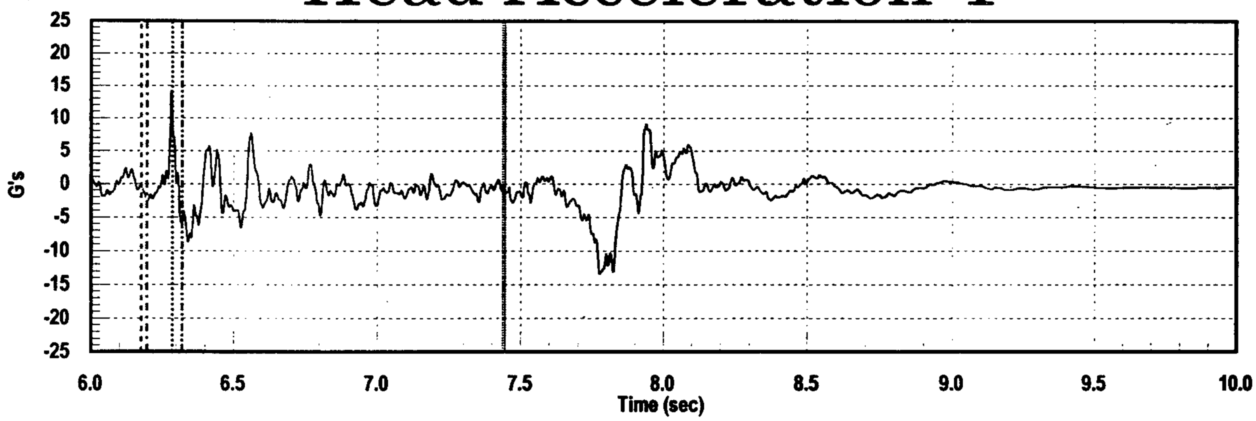
A-5

SL1050, 532 KEAS

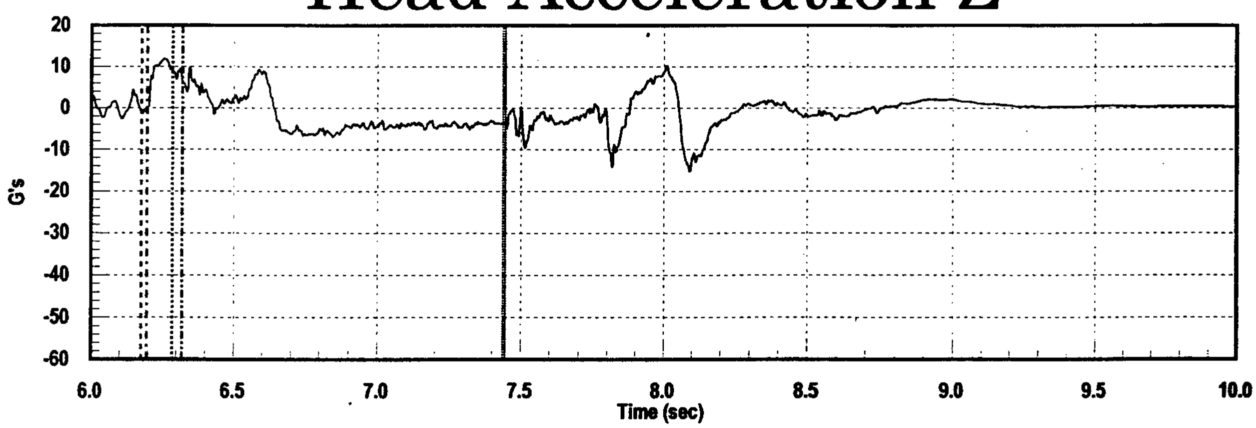
Head Acceleration X



Head Acceleration Y



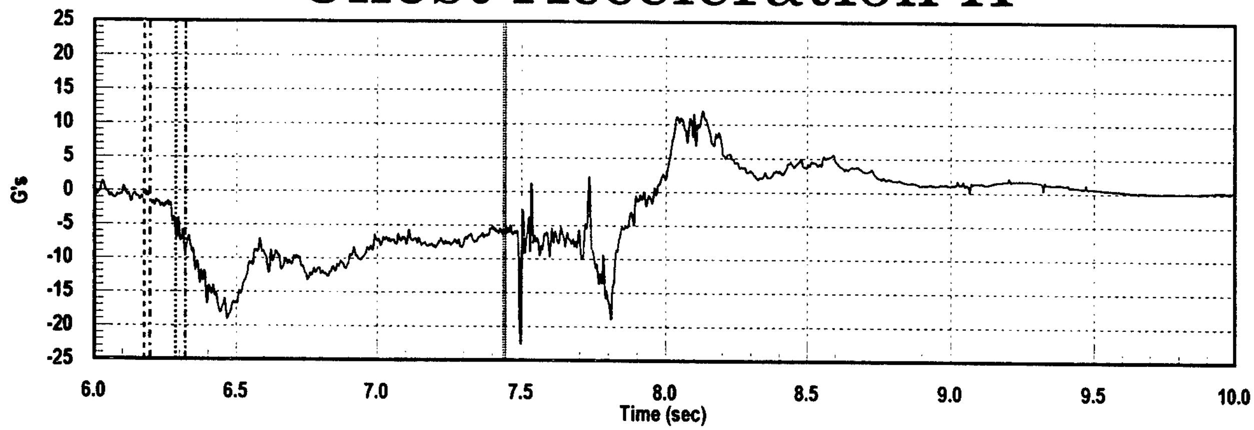
Head Acceleration Z



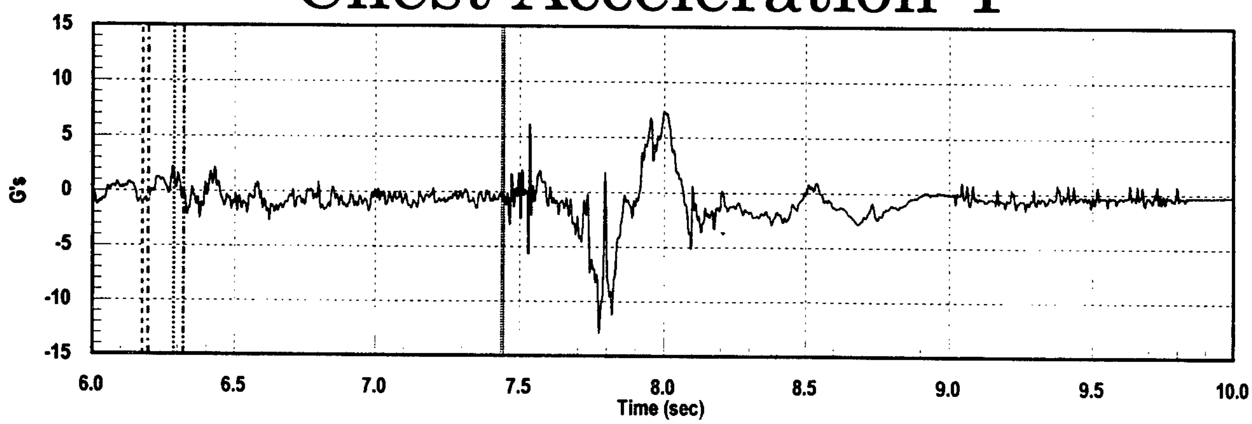
A-6

SL1050, 532 KEAS

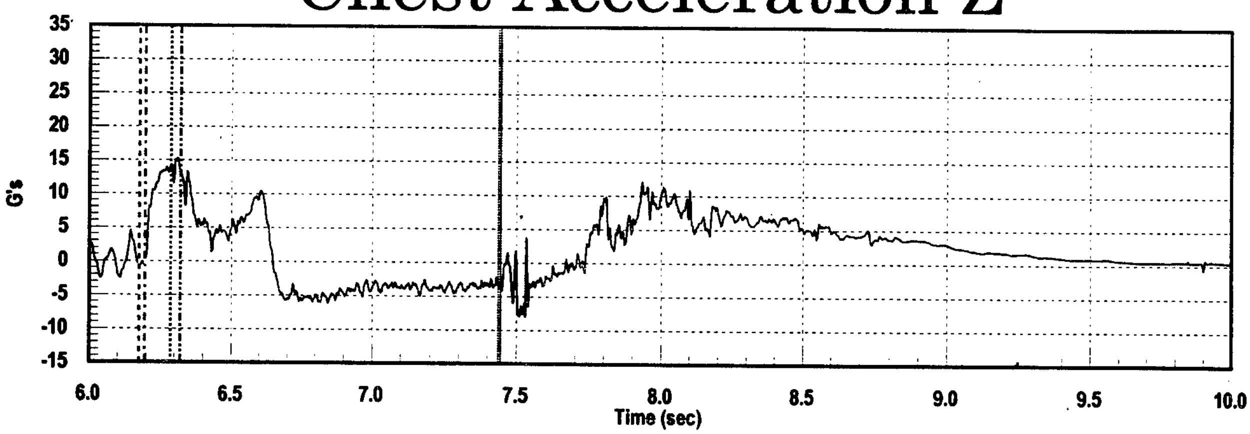
Chest Acceleration X



Chest Acceleration Y



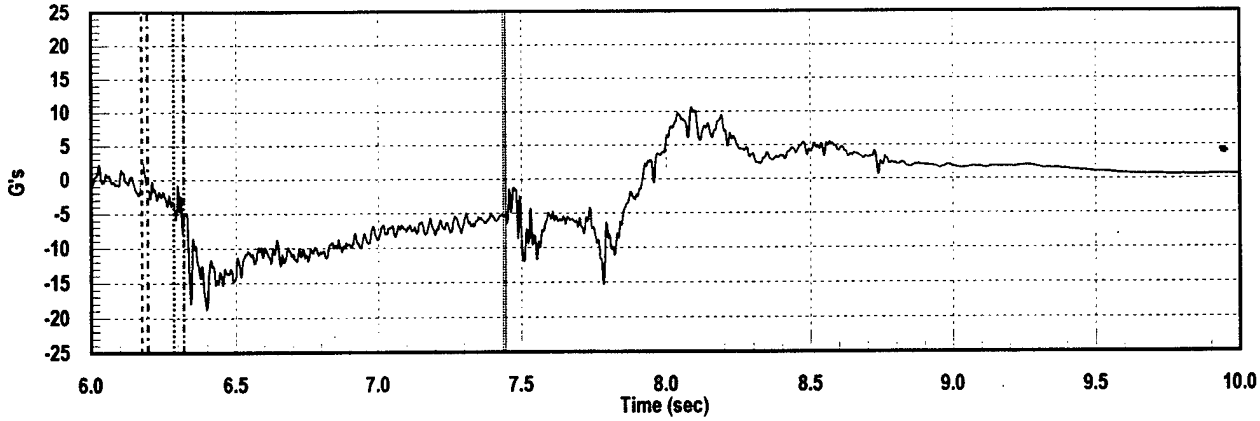
Chest Acceleration Z



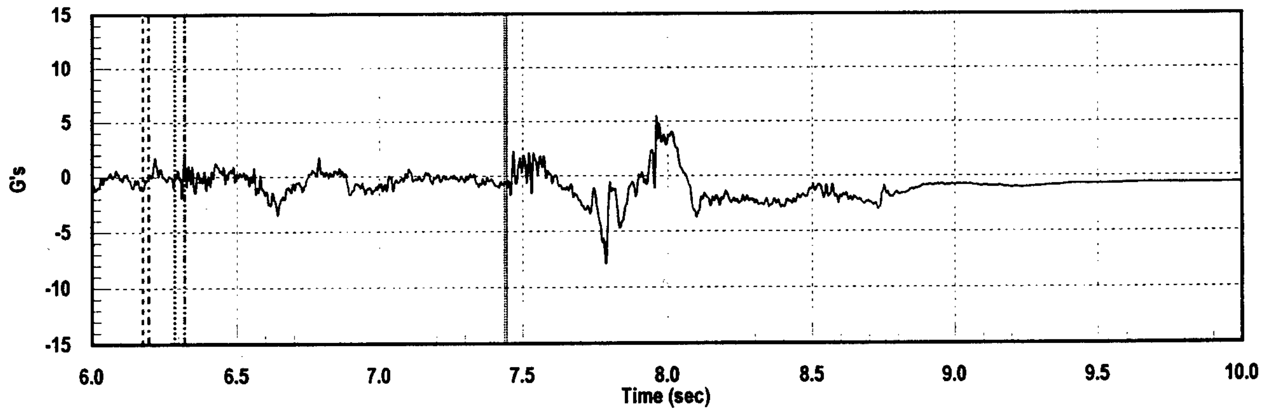
A-7

SL1050, 532 KEAS

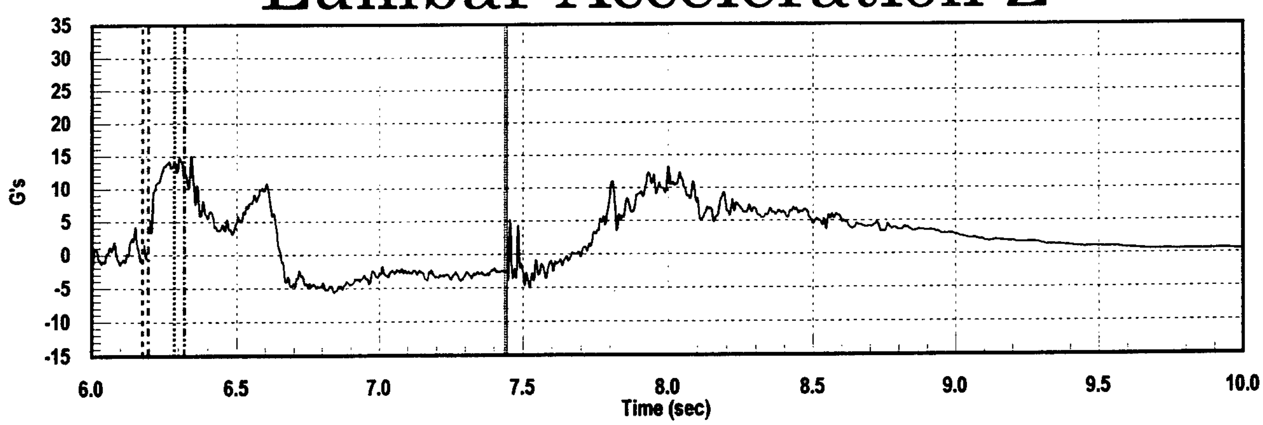
Lumbar Acceleration X



Lumbar Acceleration Y



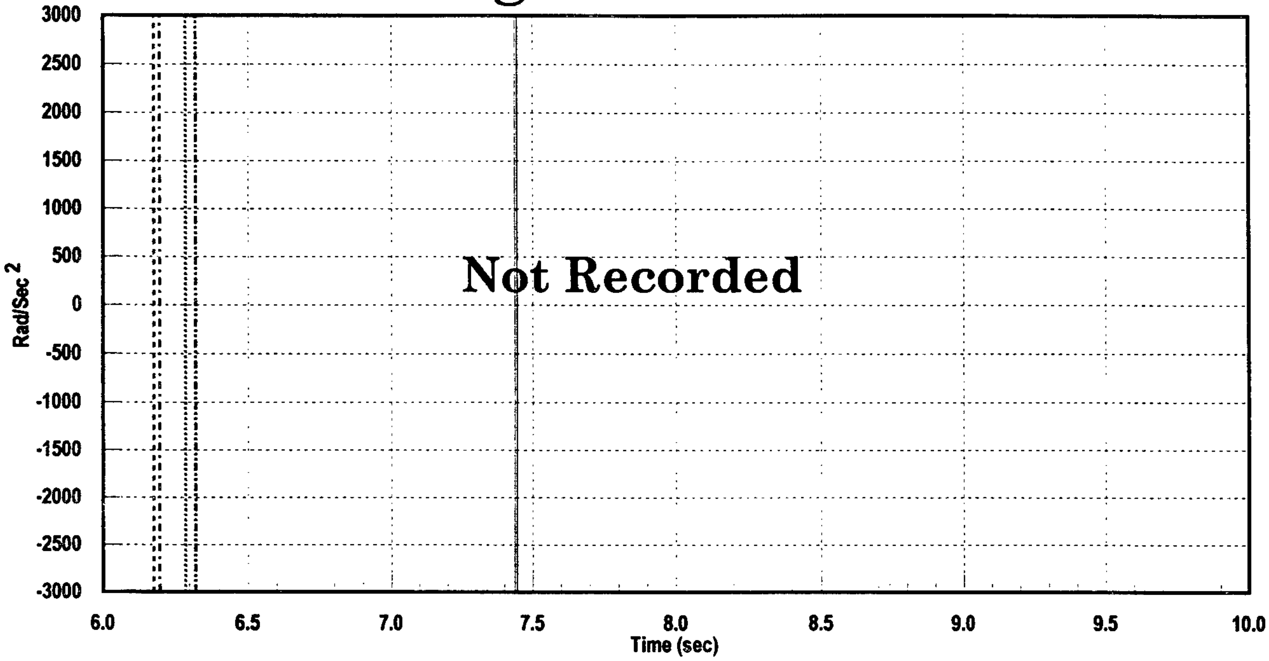
Lumbar Acceleration Z



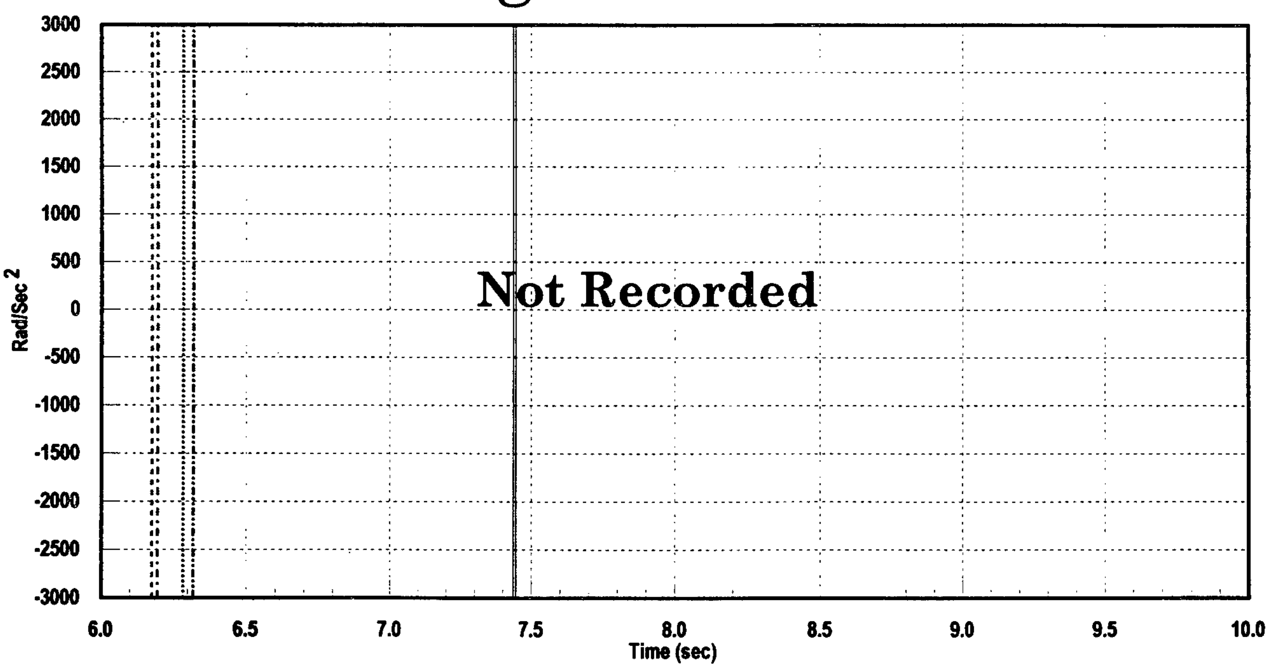
A-8

SL1050, 532 KEAS

Head Angular Acceleration Y

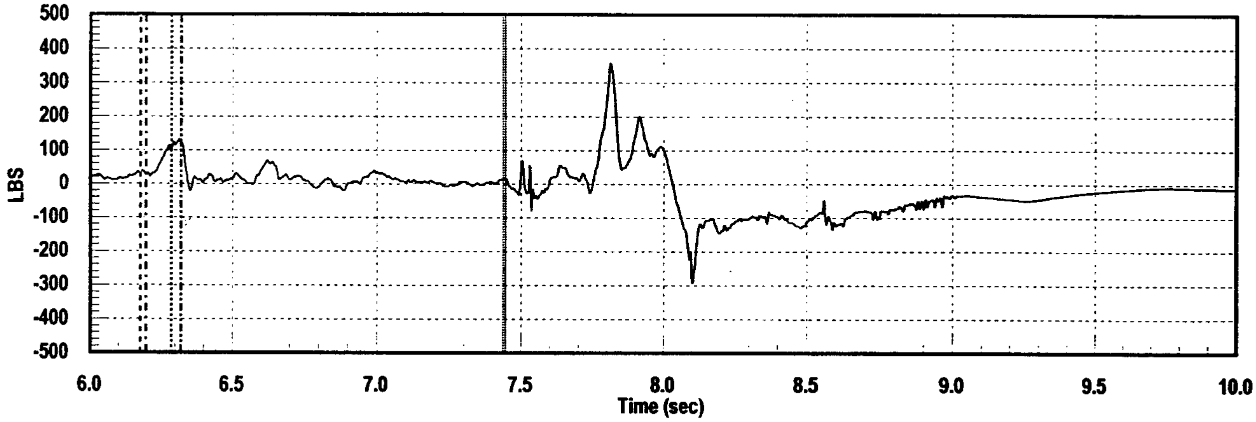


Chest Angular Acceleration Y

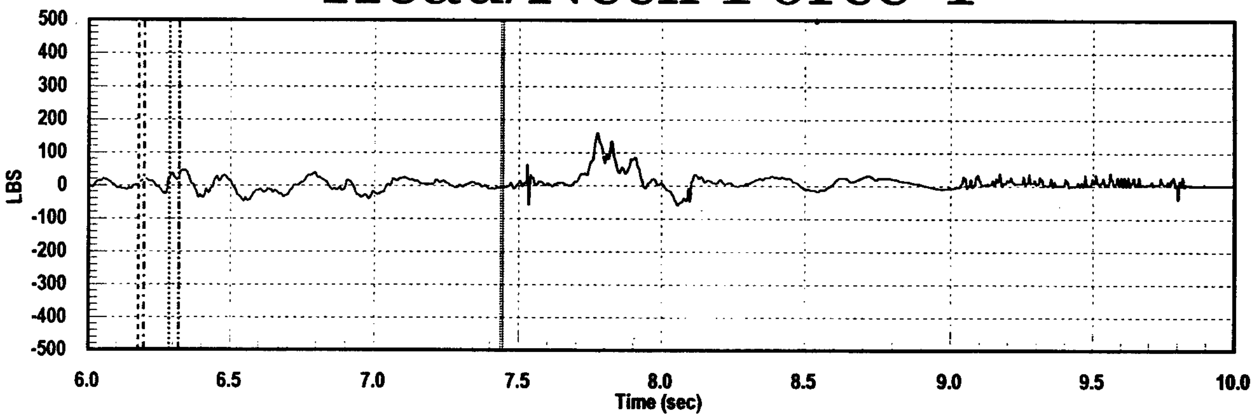


SL1050, 532 KEAS

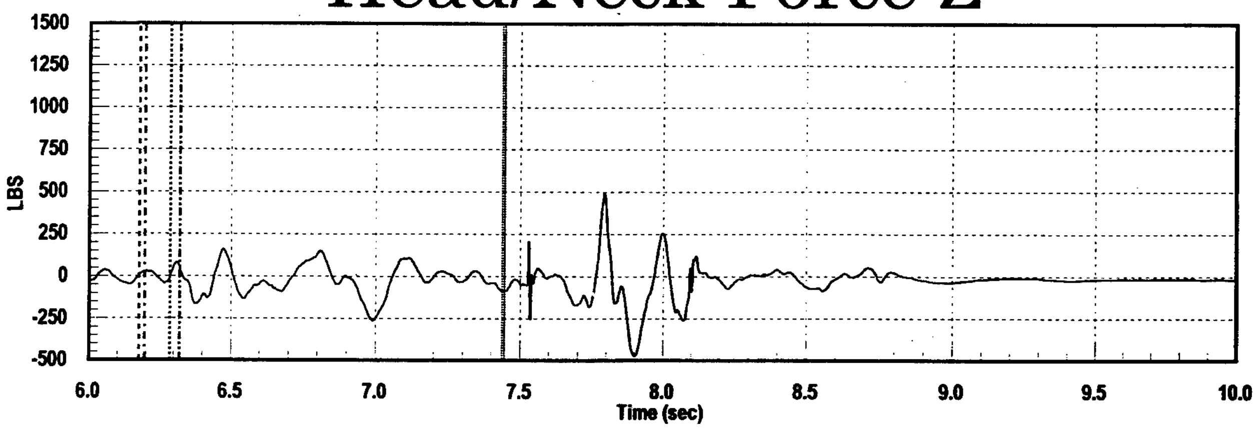
Head/Neck Force X



Head/Neck Force Y



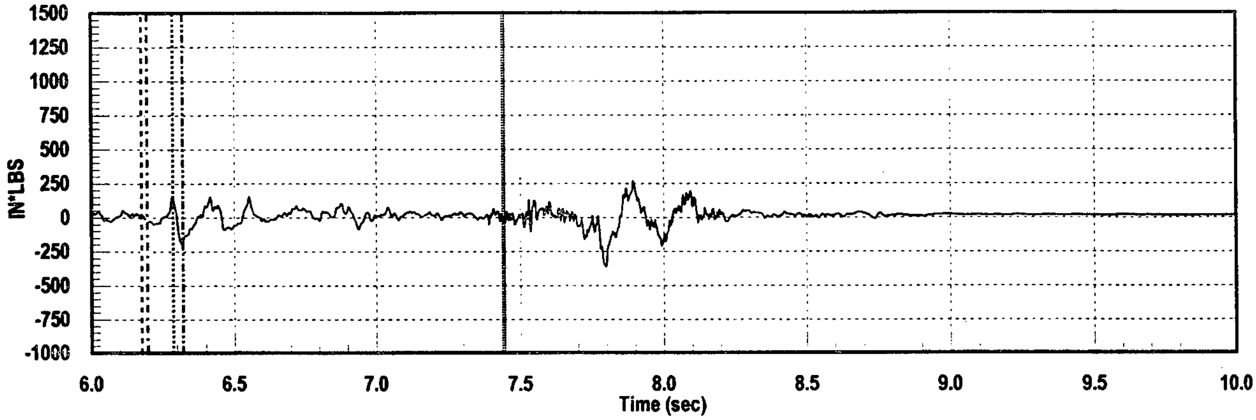
Head/Neck Force Z



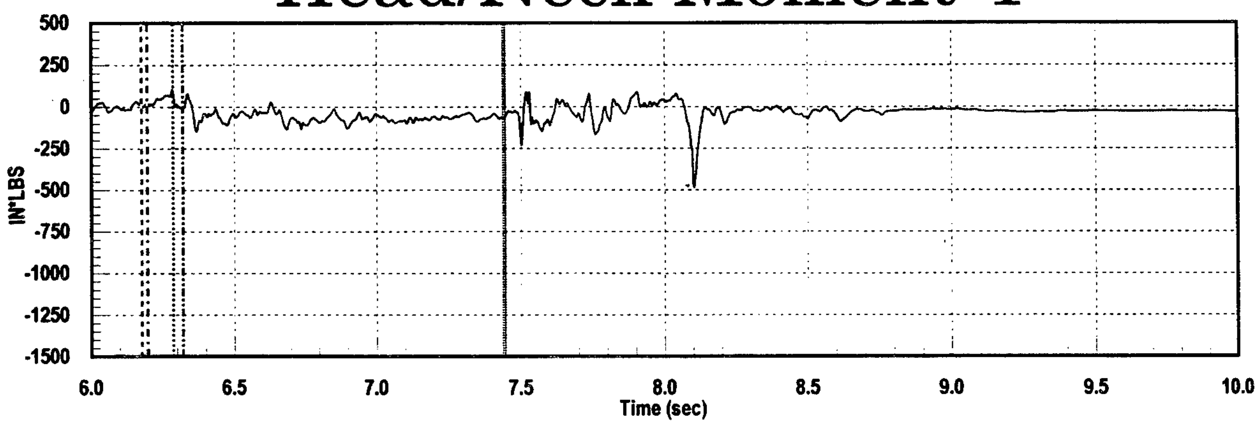
A-10

SL1050, 532 KEAS

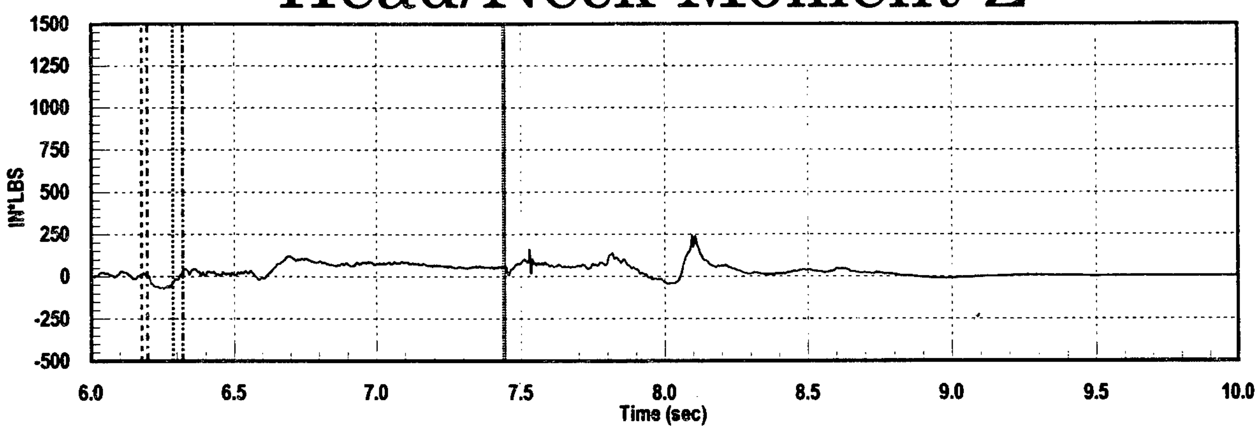
Head/Neck Moment X



Head/Neck Moment Y

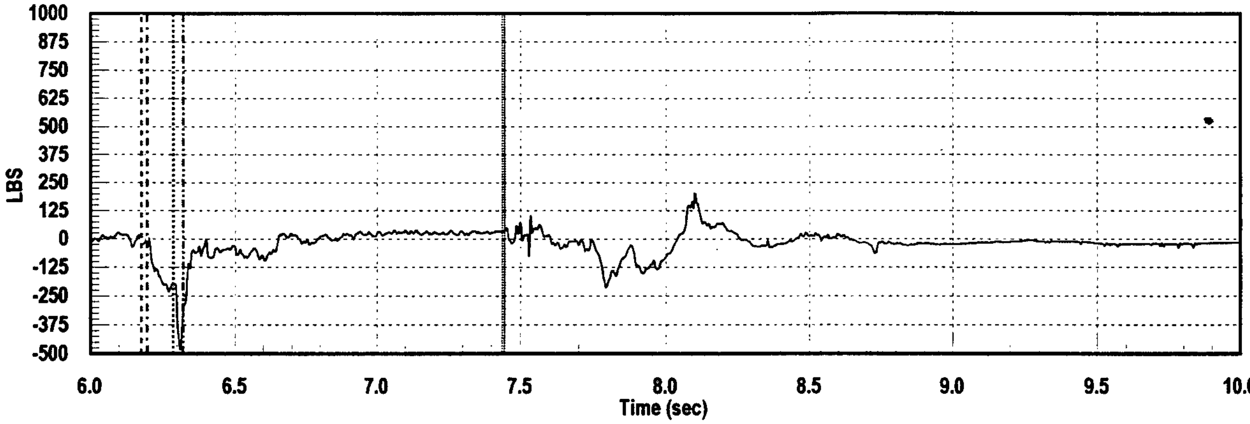


Head/Neck Moment Z

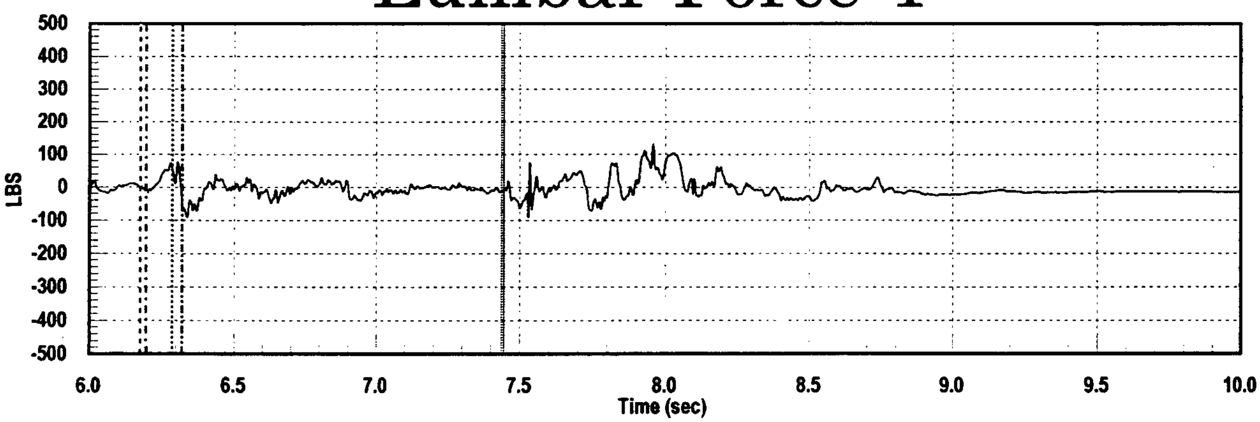


SL1050, 532 KEAS

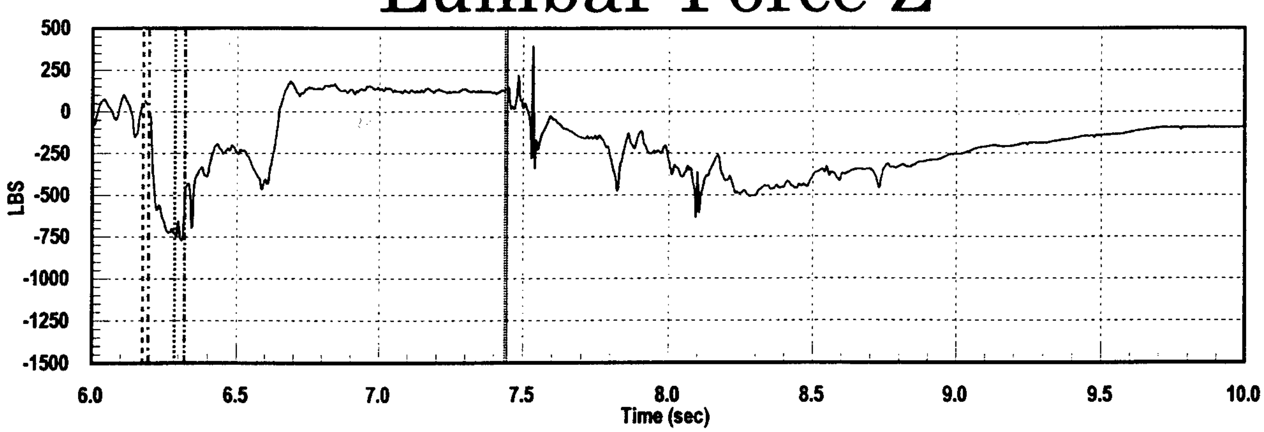
Lumbar Force X



Lumbar Force Y



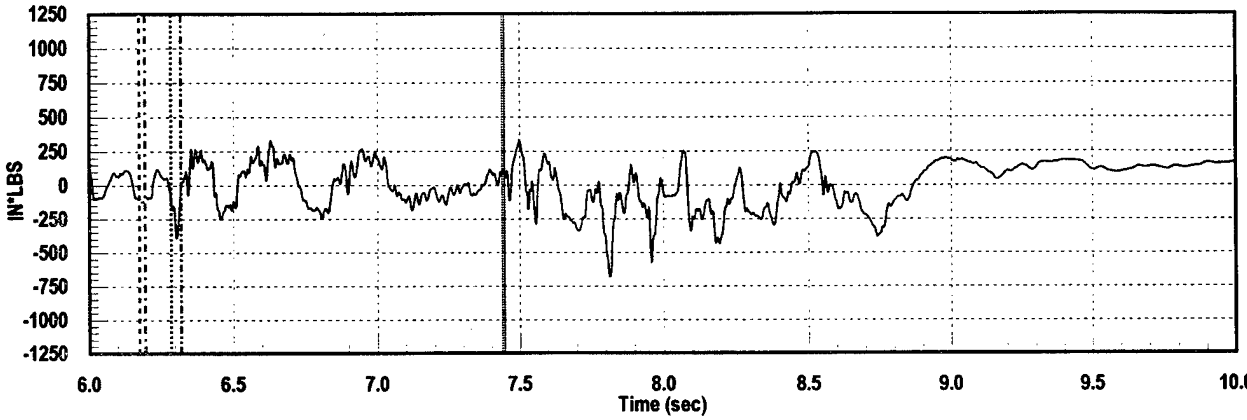
Lumbar Force Z



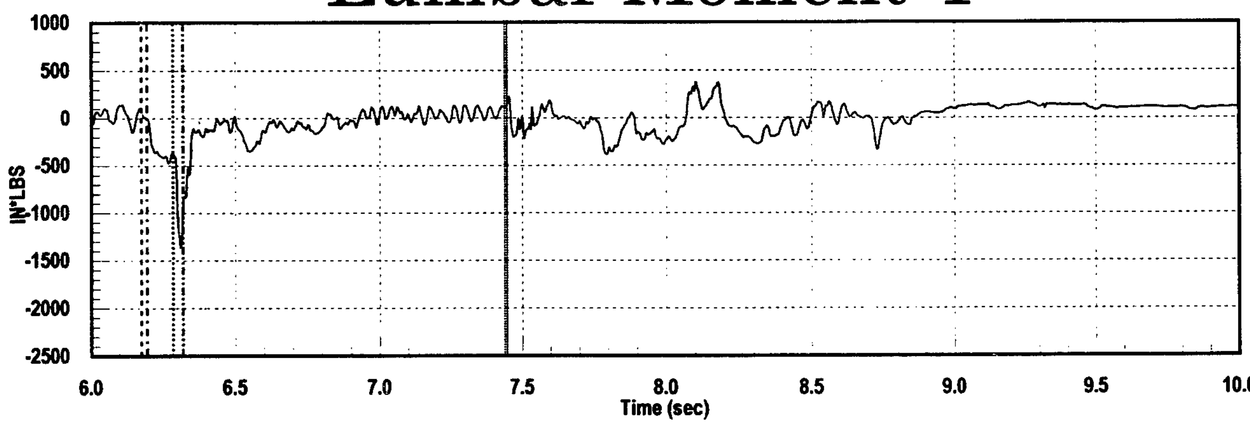
A-12

SL1050, 532 KEAS

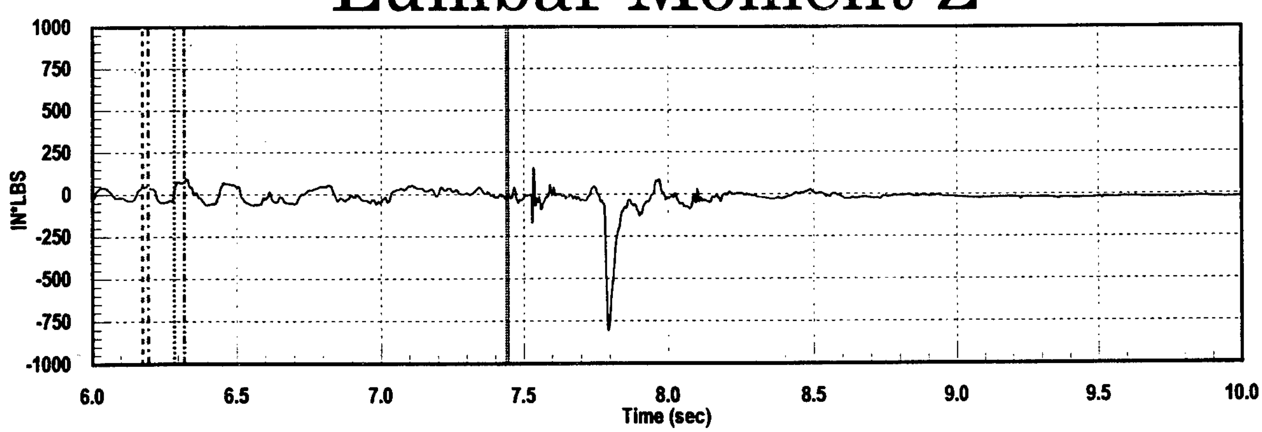
Lumbar Moment X



Lumbar Moment Y



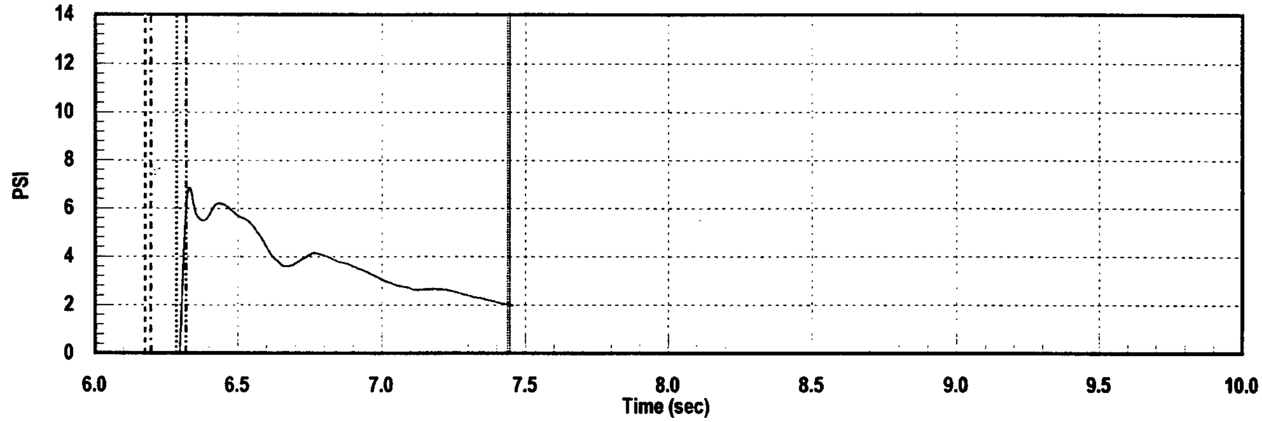
Lumbar Moment Z



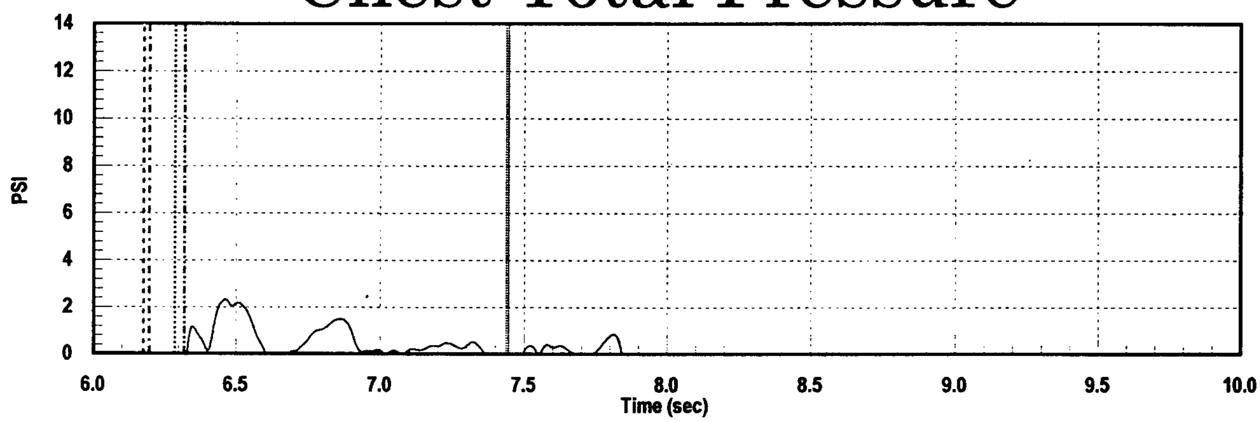
A-13

SL1050, 532 KEAS

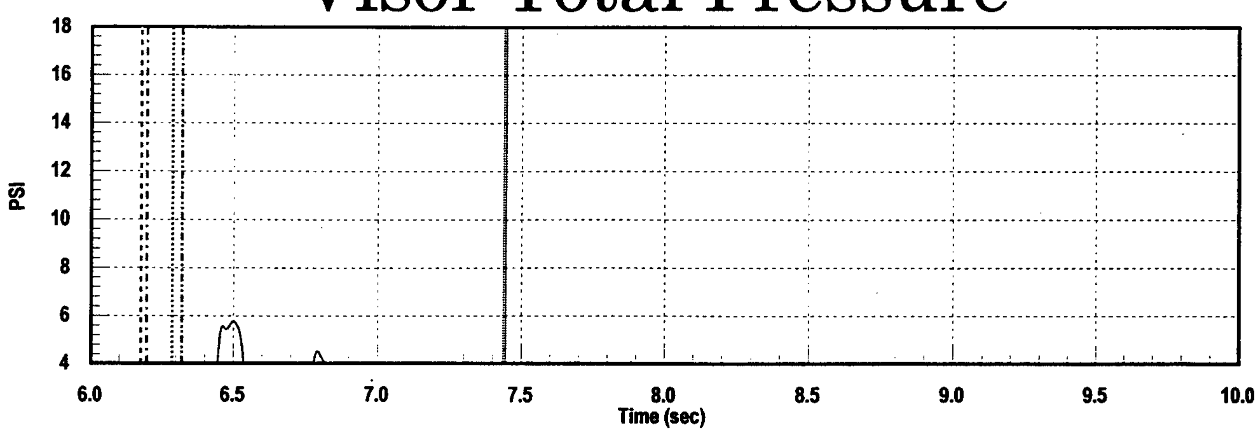
Windblast Deflector Total Pressure



Chest Total Pressure



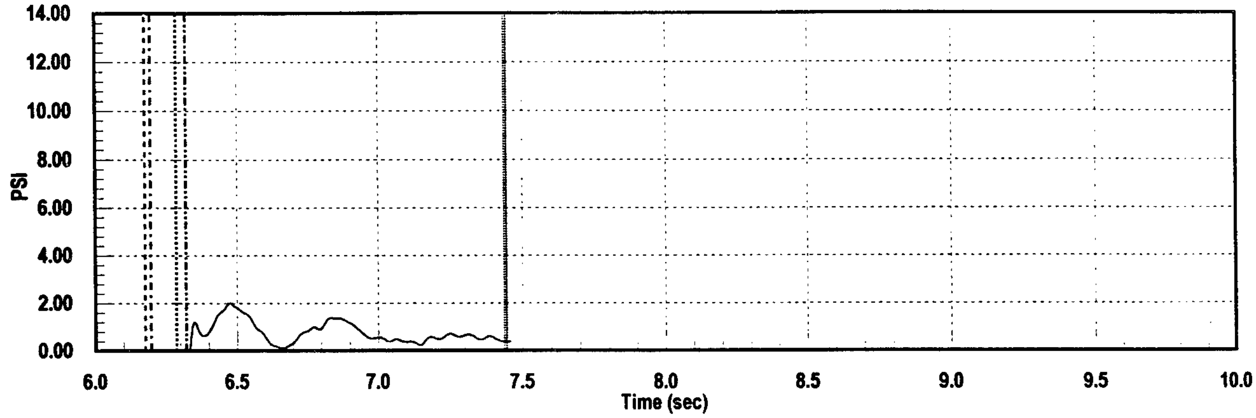
Visor Total Pressure



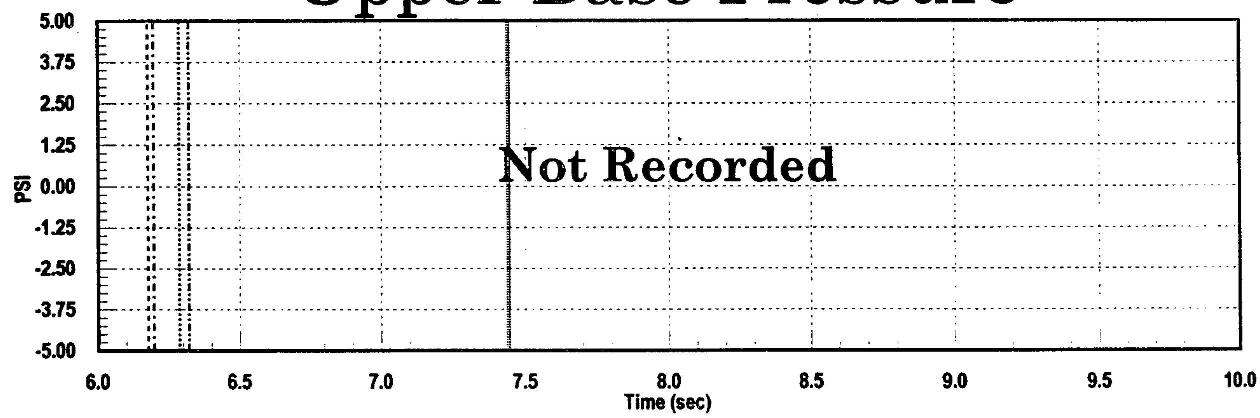
A-14

SL1050, 532 KEAS

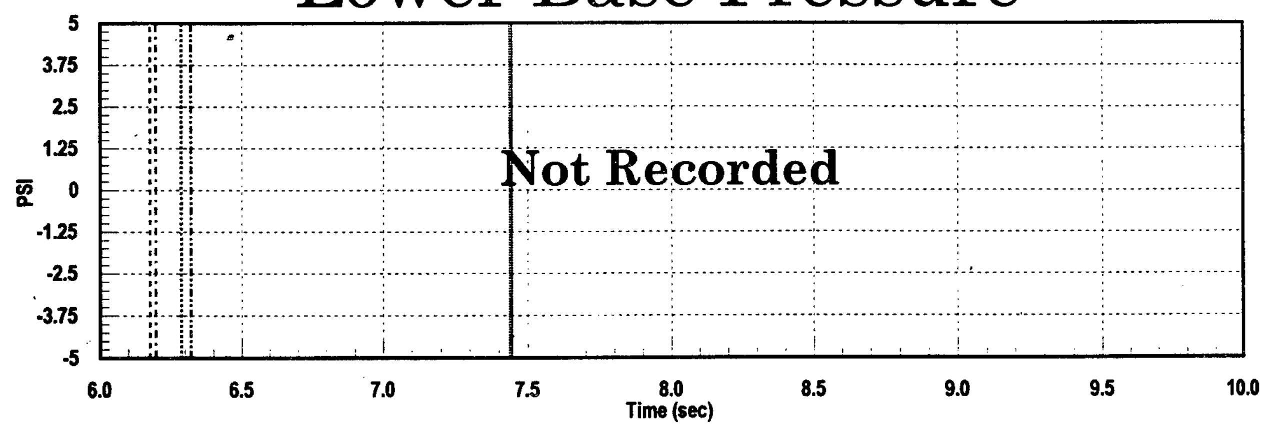
Windblast Deflector Static Pressure



Upper Base Pressure



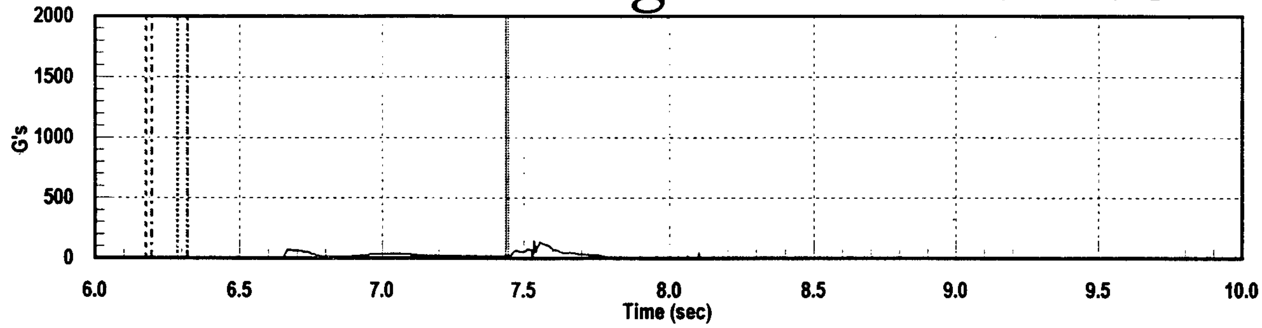
Lower Base Pressure



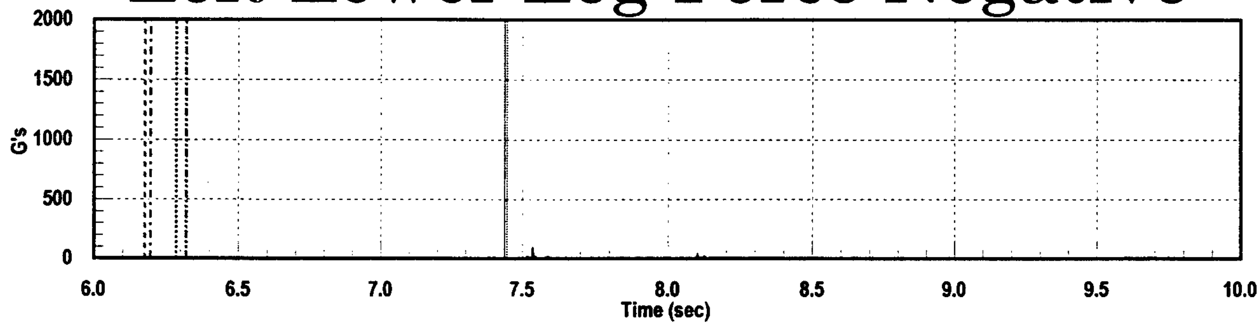
A-15

SL1050, 532 KEAS

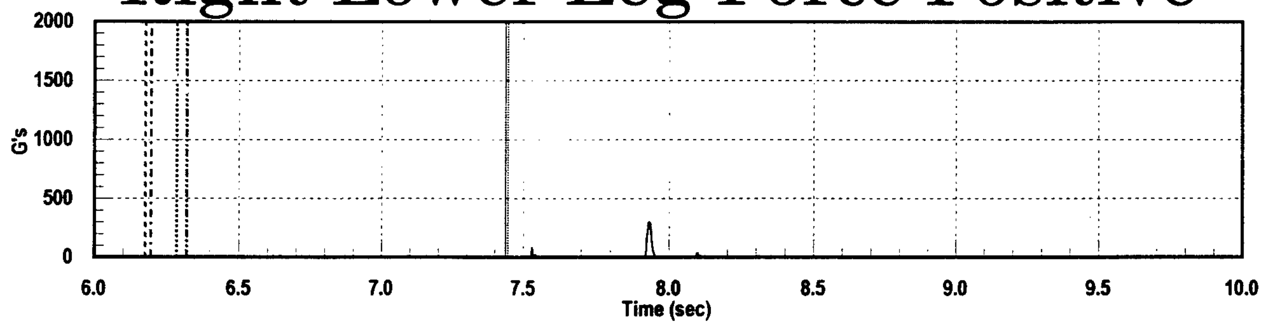
Left Lower Leg Force Positive



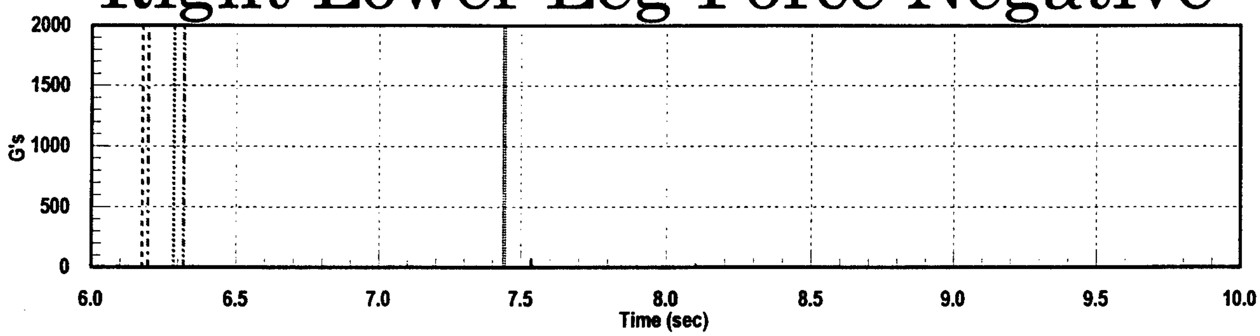
Left Lower Leg Force Negative



Right Lower Leg Force Positive



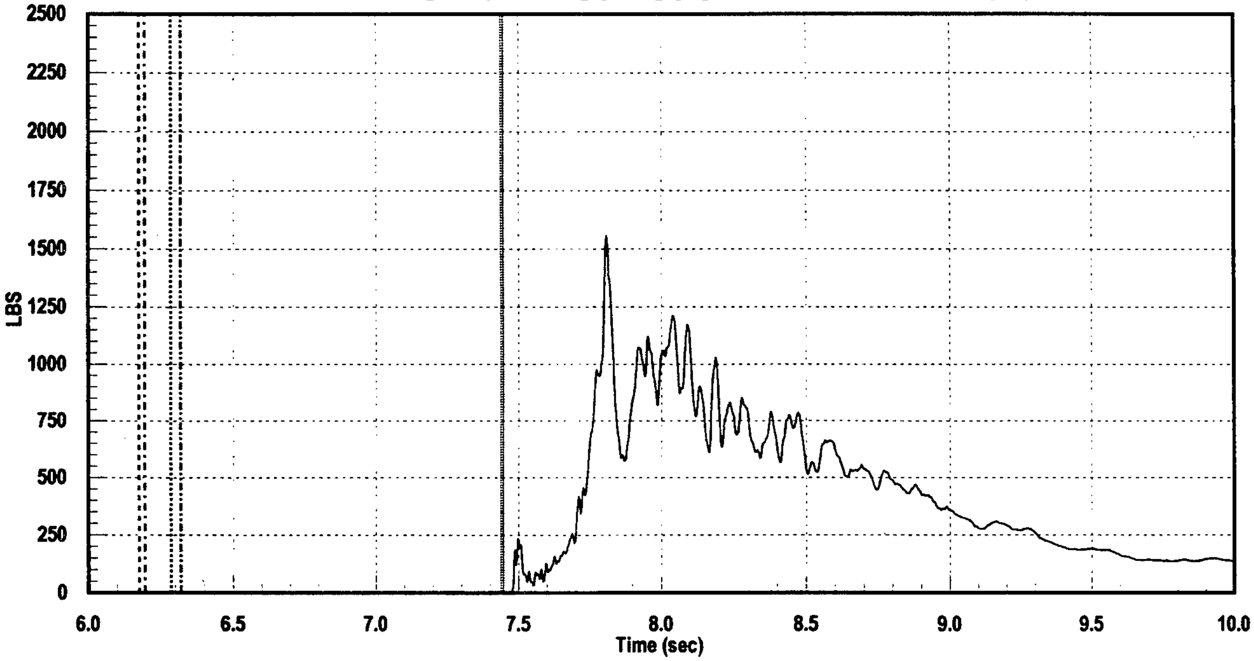
Right Lower Leg Force Negative



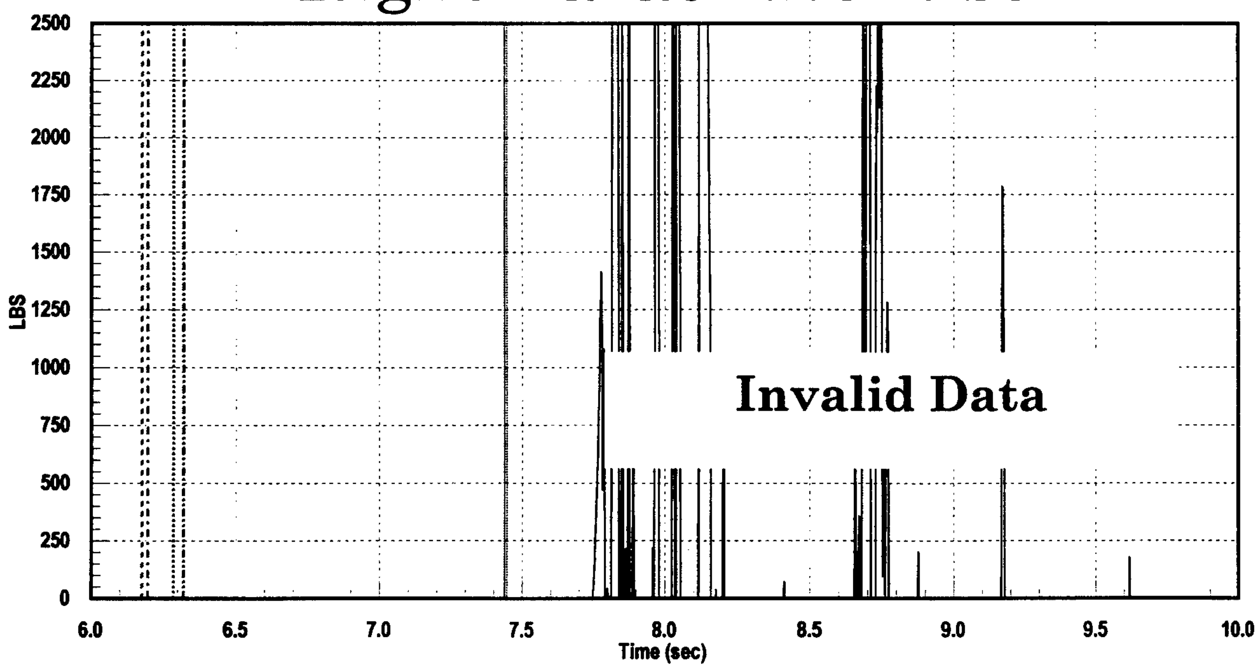
A-16

SL1050, 532 KEAS

Left Parachute Riser



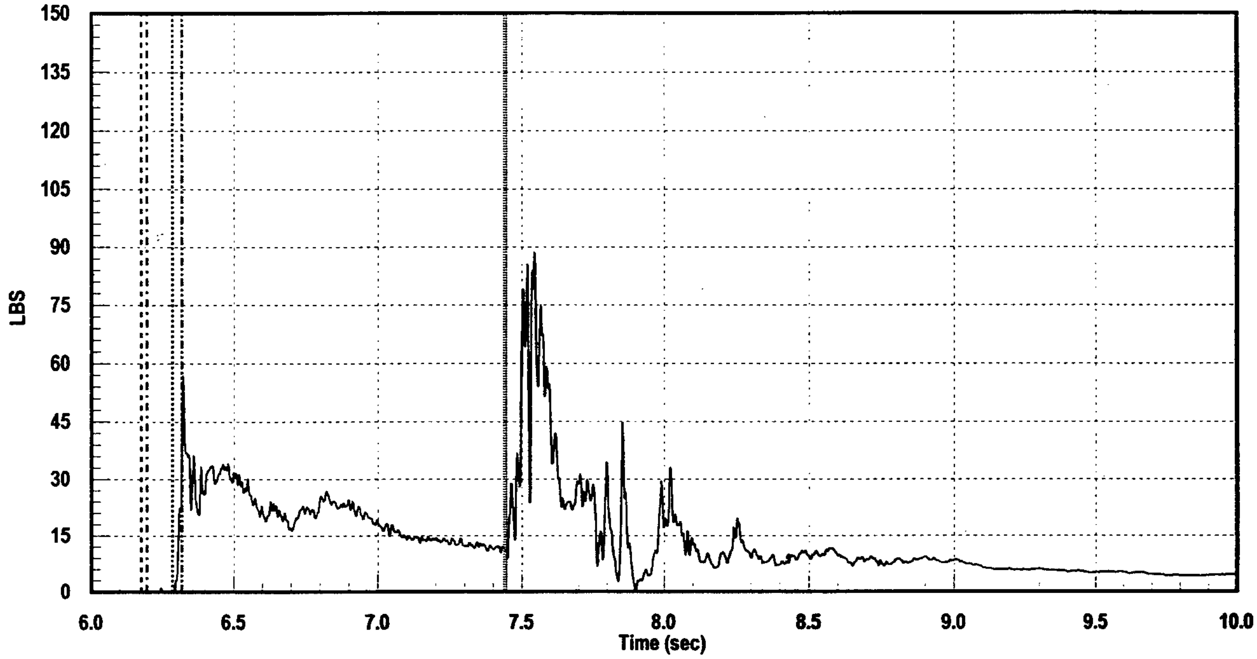
Right Parachute Riser



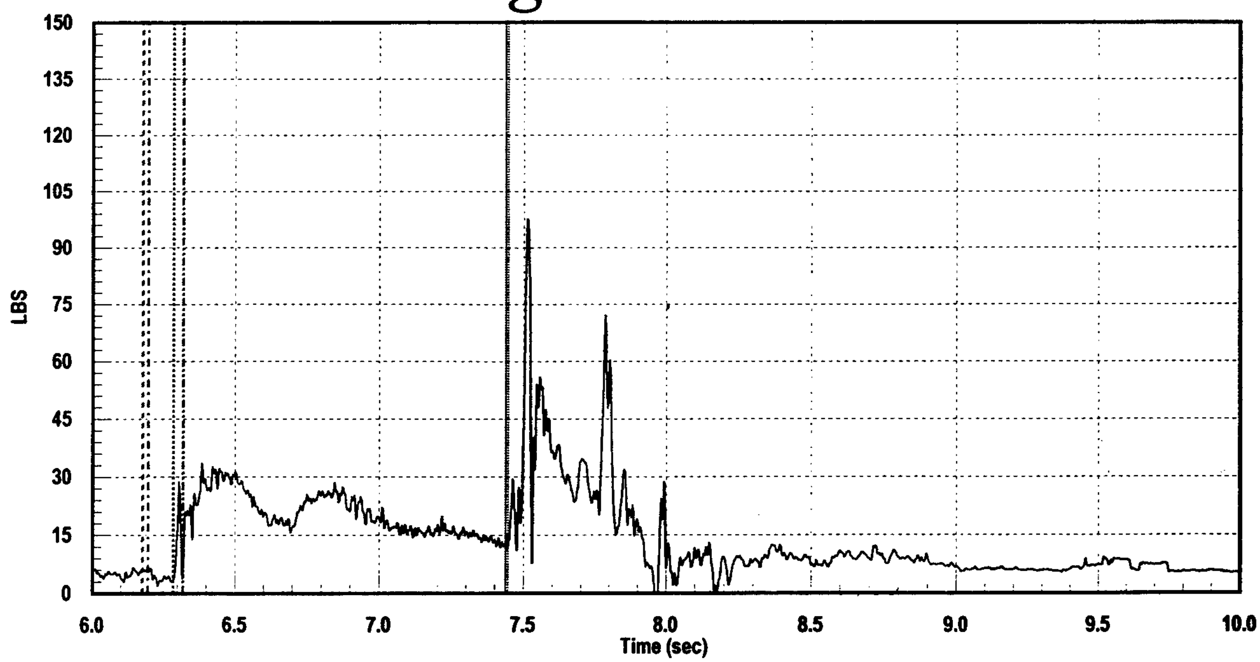
A-17

SL1050, 532 KEAS

Left Arm Lift



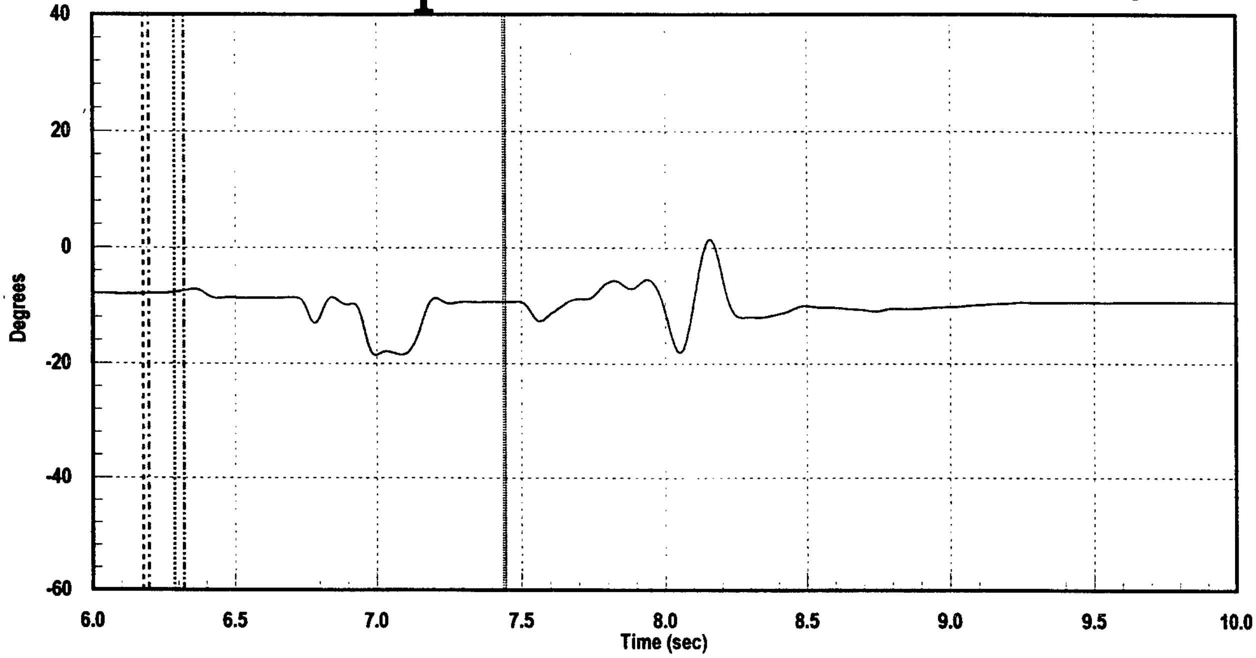
Right Arm Lift



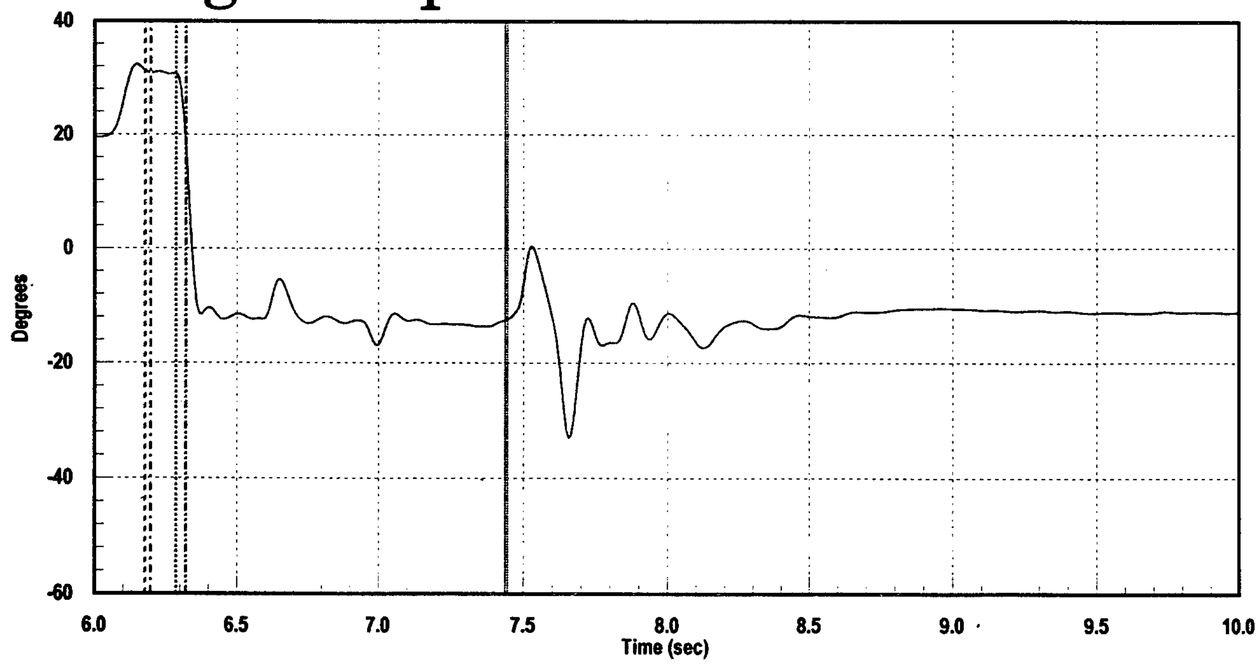
A-18

SL1050, 532 KEAS

Left Hip Abduction/Adduction



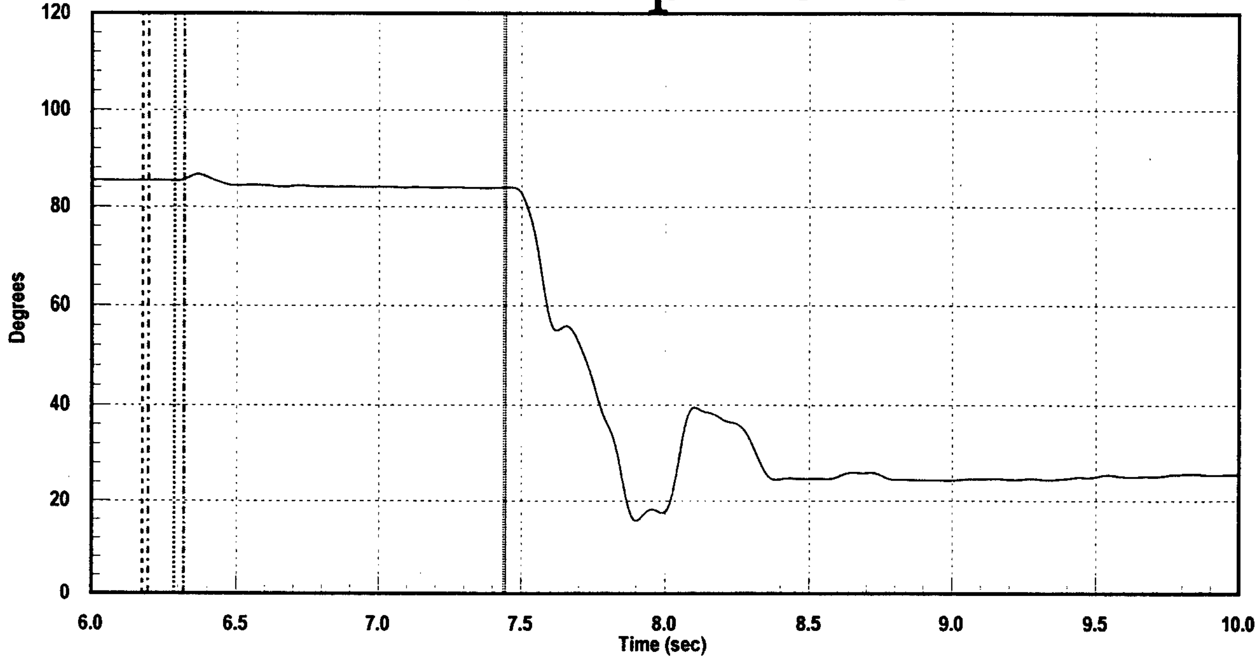
Right Hip Abduction/Adduction



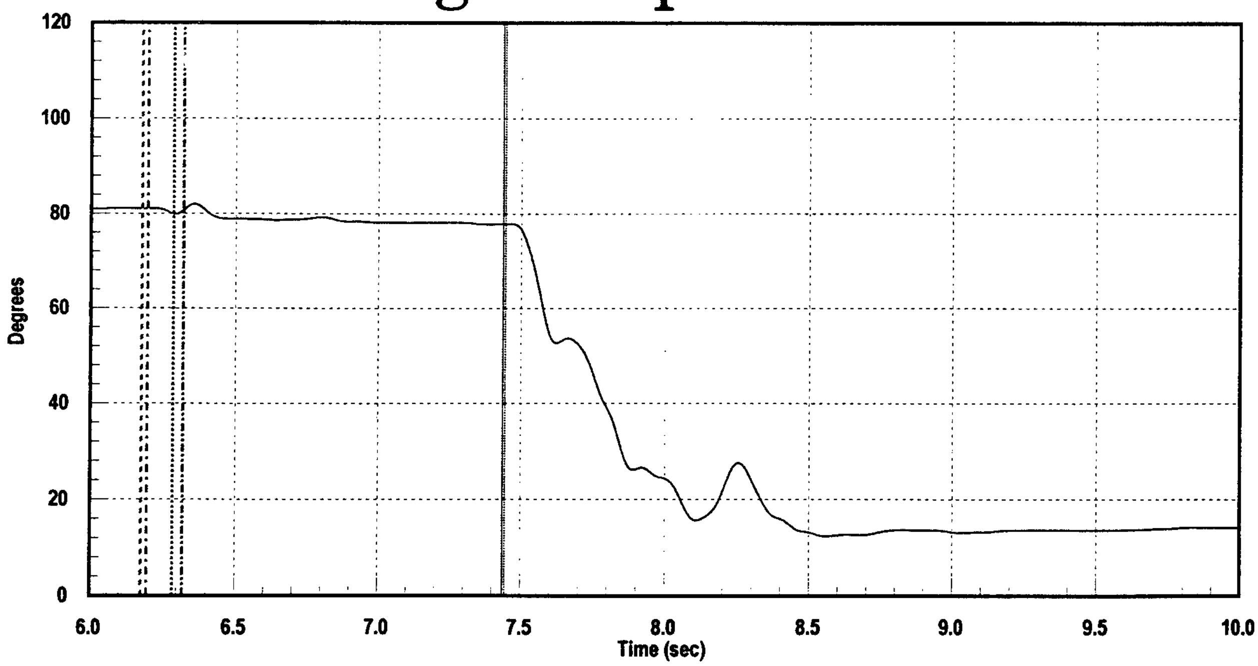
A-19

SL1050, 532 KEAS

Left Hip Flexion



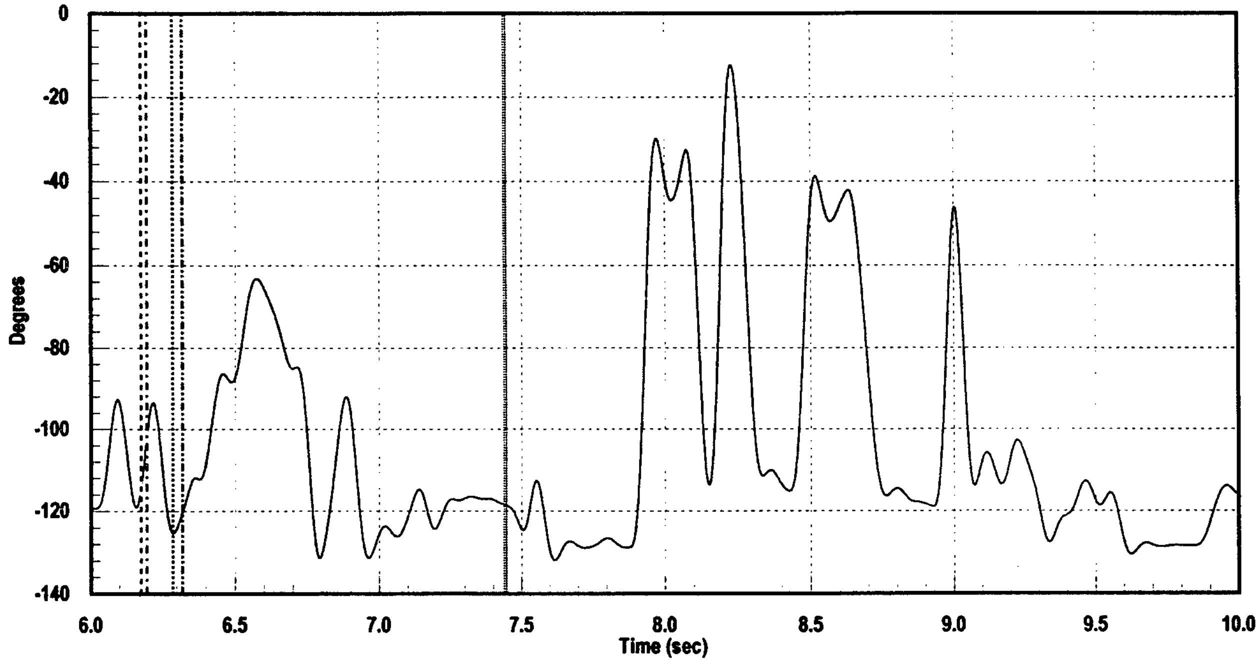
Right Hip Flexion



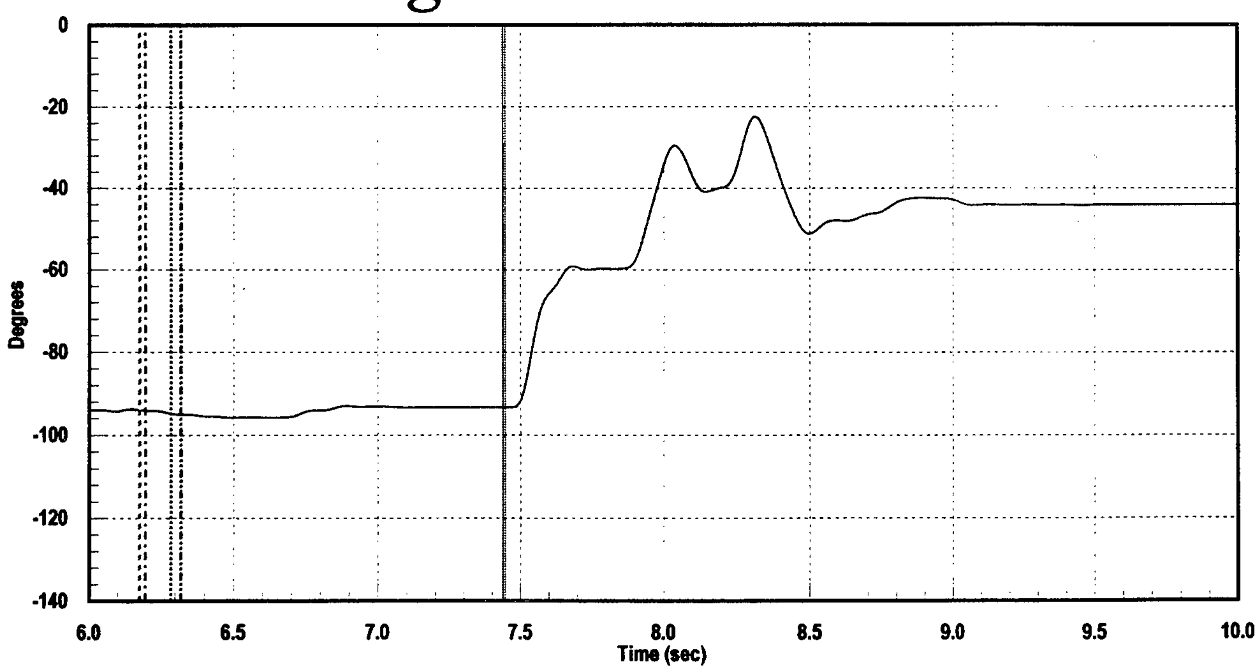
A-20

SL1050, 532 KEAS

Left Knee Flexion



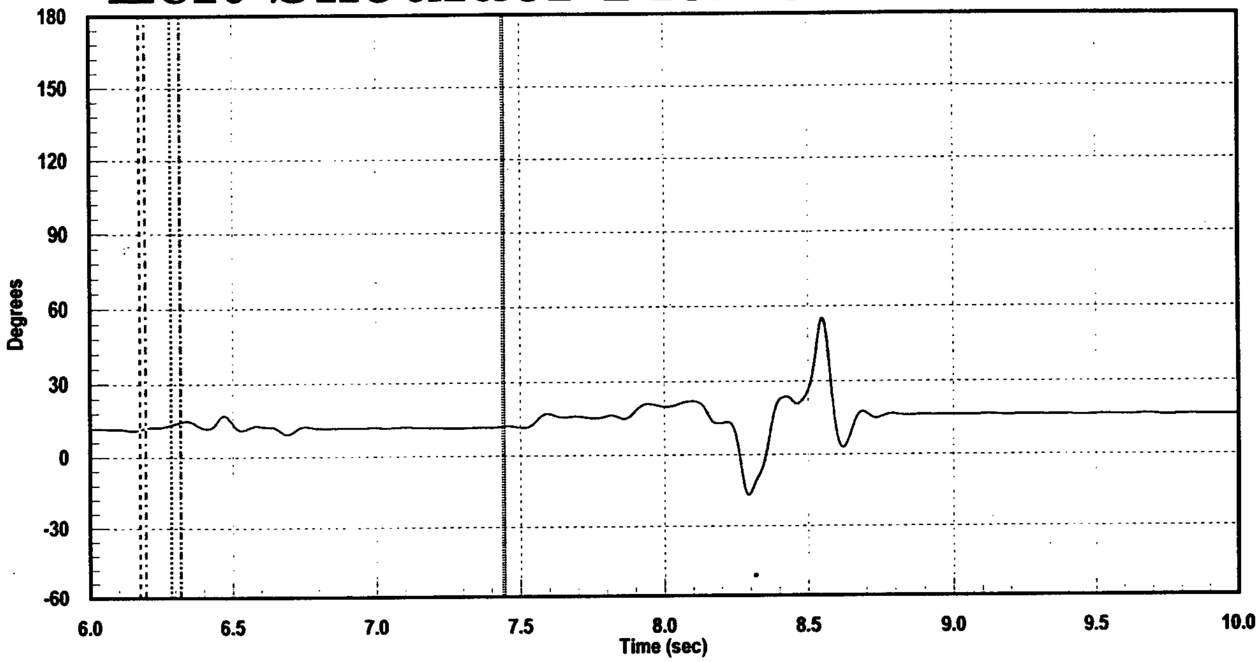
Right Knee Flexion



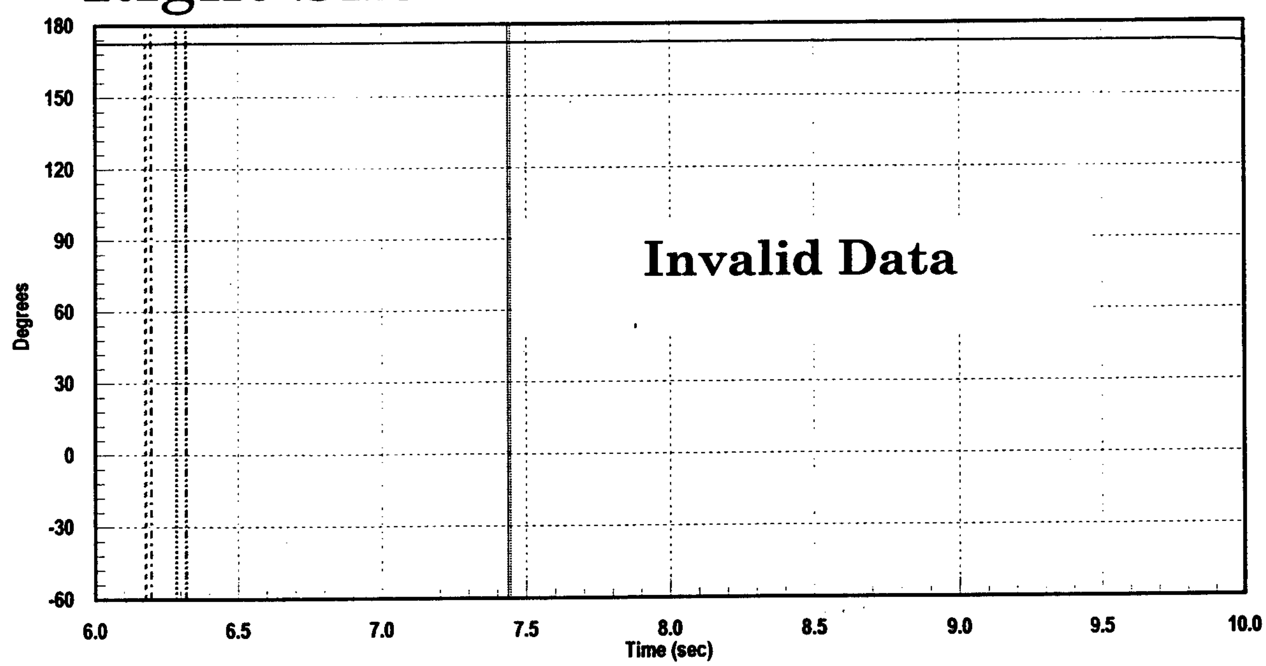
A-21

SL1050, 532 KEAS

Left Shoulder Flexion/Extenstion



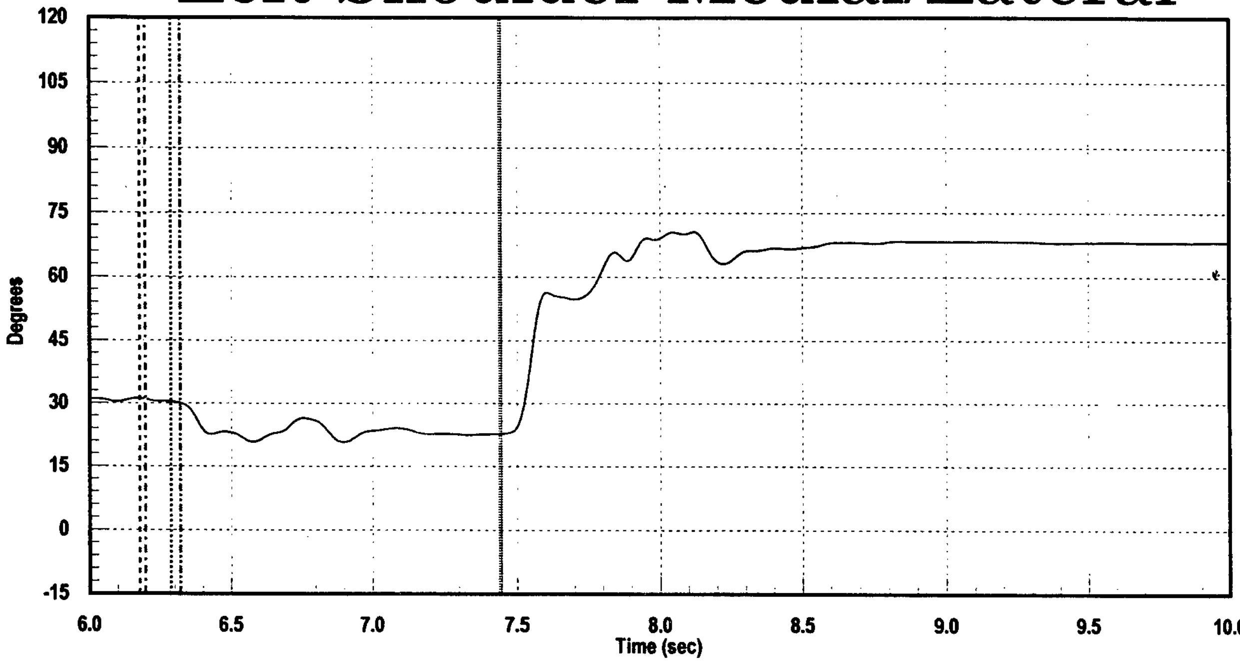
Right Shoulder Flexion/Extension



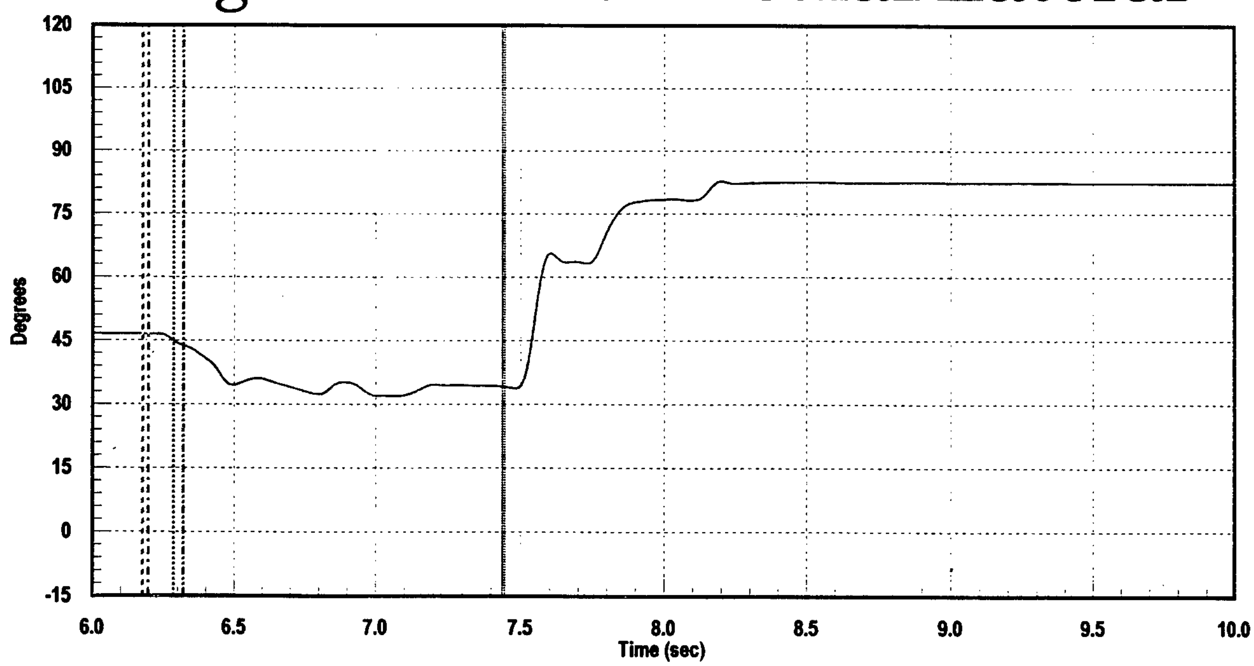
A-22

SL1050, 532 KEAS

Left Shoulder Medial/Lateral



Right Shoulder Medial/Lateral



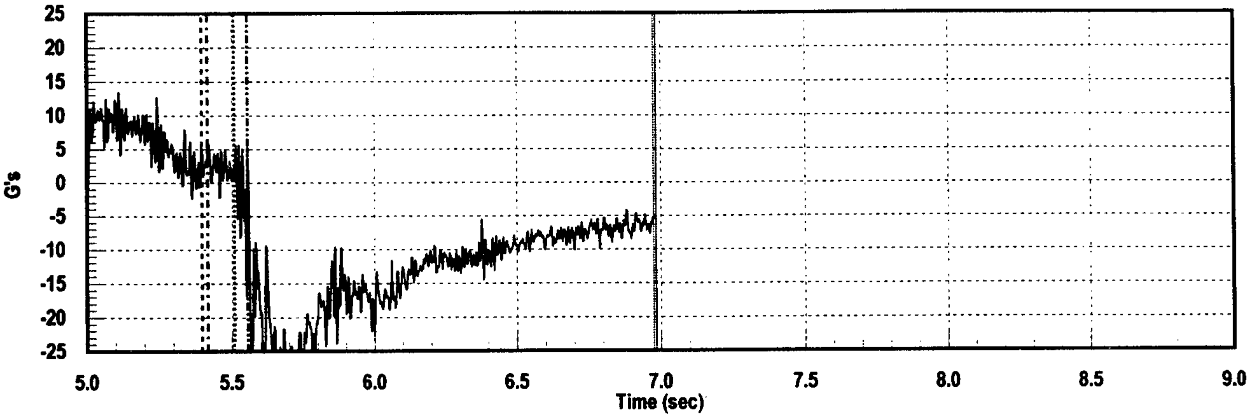
A-23

SL1295, 694 KEAS
Processed Data

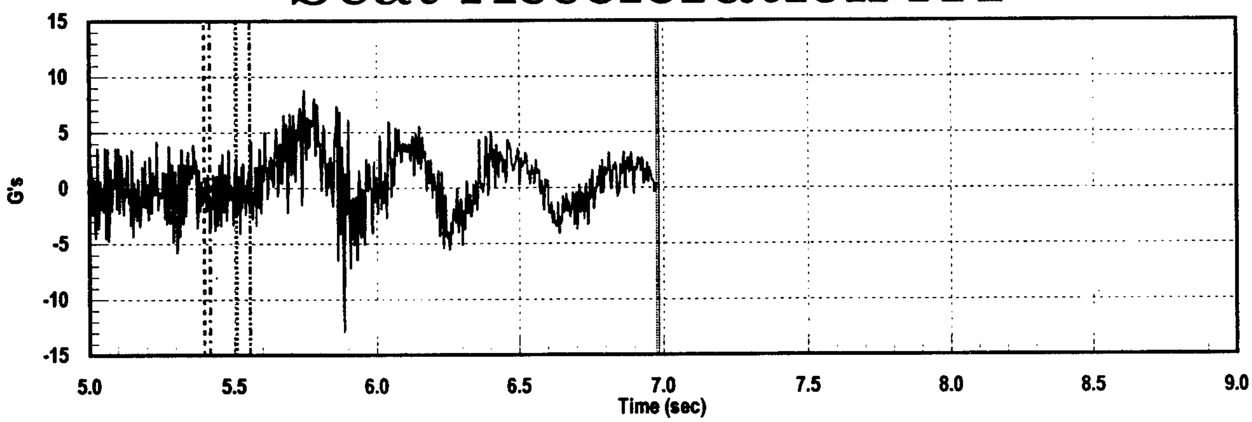
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

SL1295, 694 KEAS

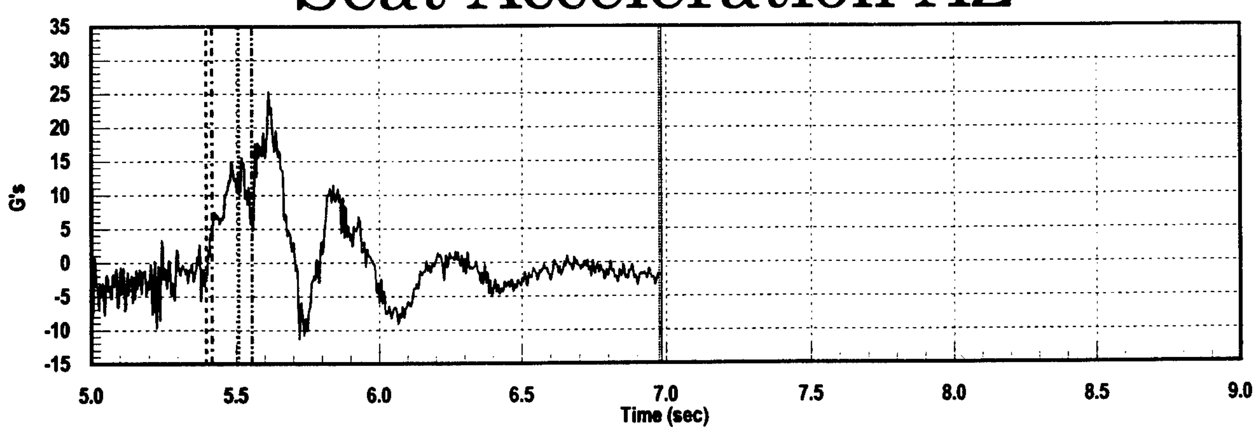
Seat Acceleration AX



Seat Acceleration AY



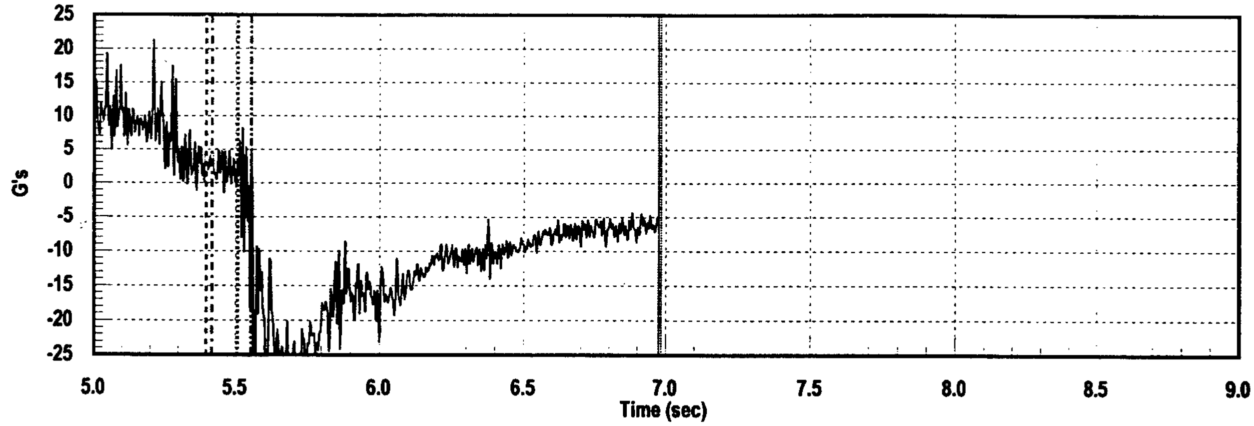
Seat Acceleration AZ



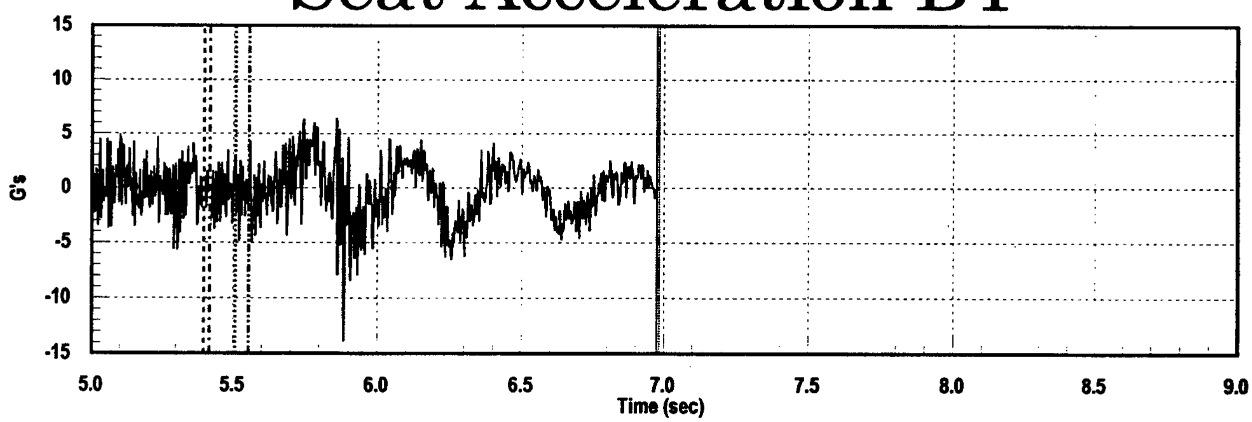
A-1

SL1295, 694 KEAS

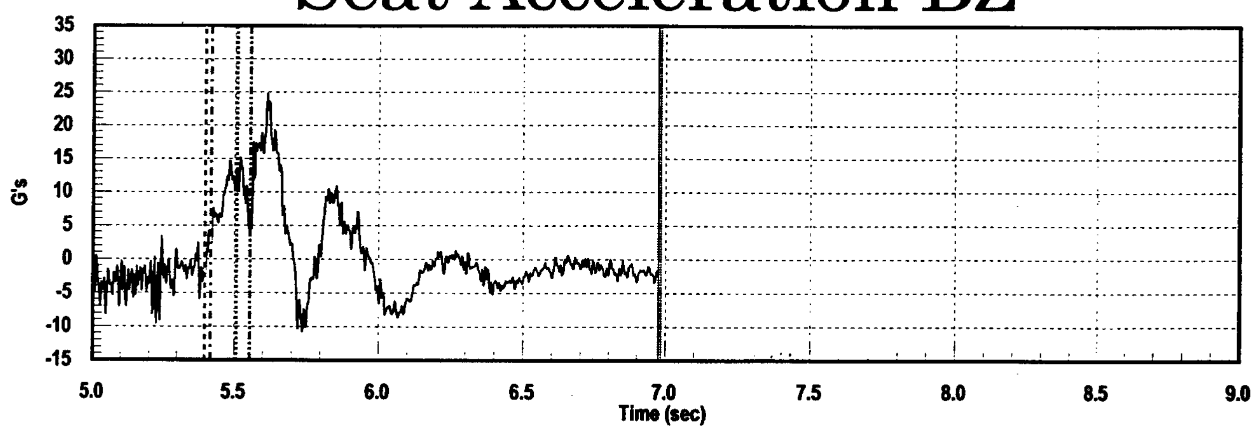
Seat Acceleration BX



Seat Acceleration BY



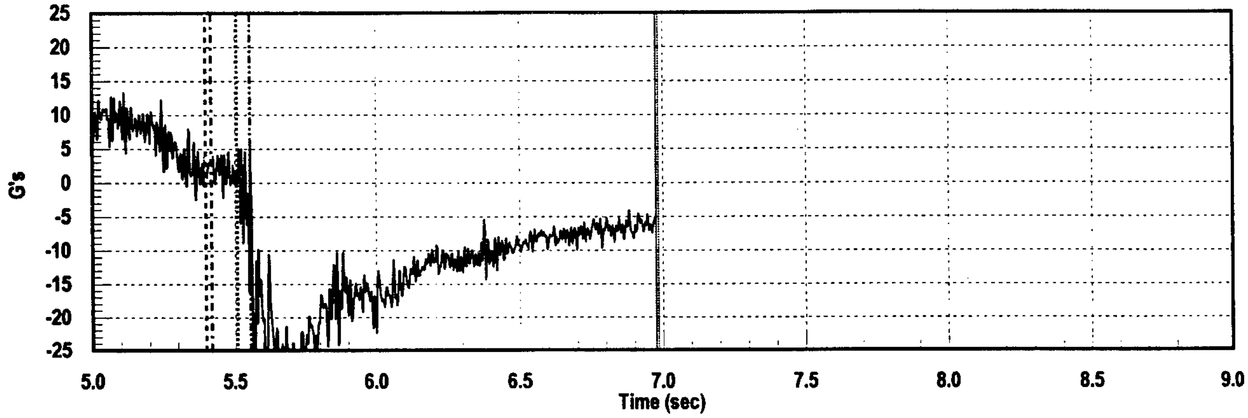
Seat Acceleration BZ



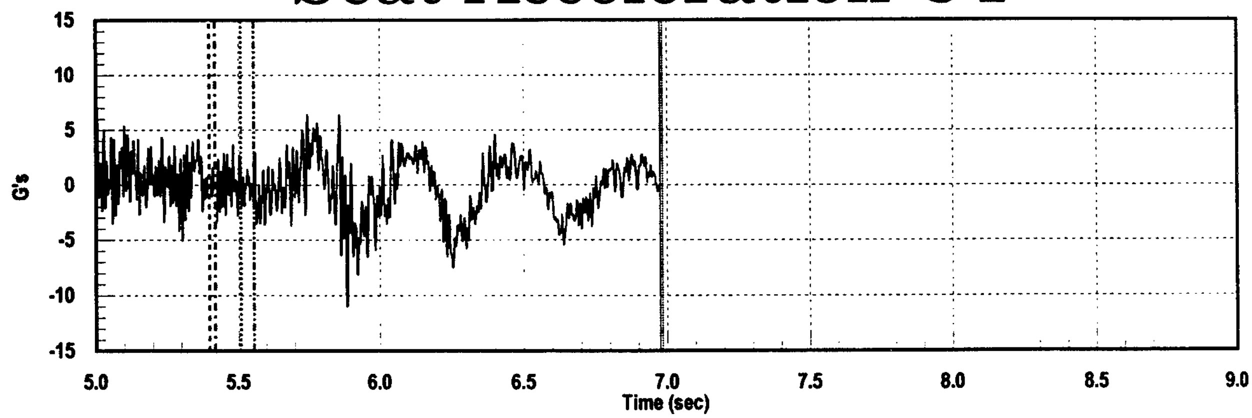
A-2

SL1295, 694 KEAS

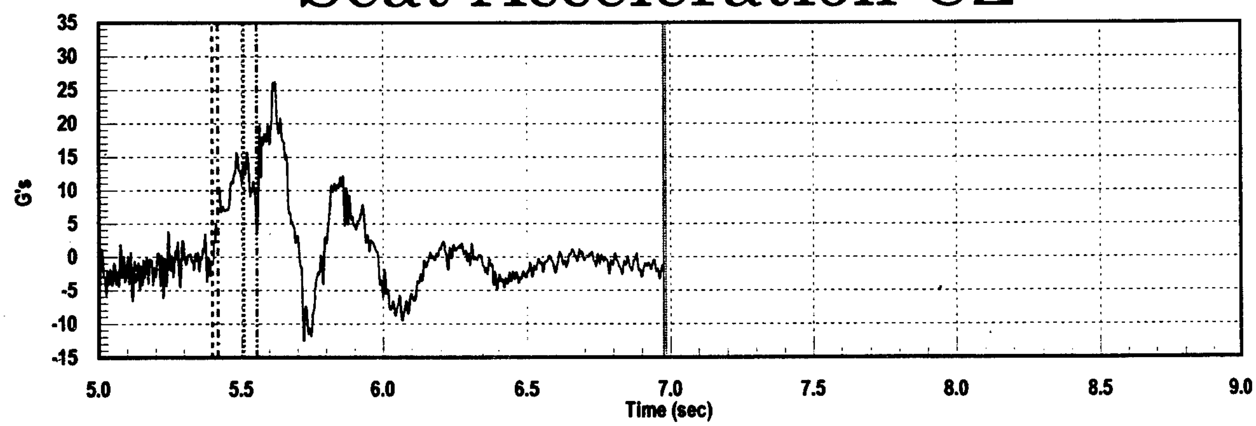
Seat Acceleration CX



Seat Acceleration CY



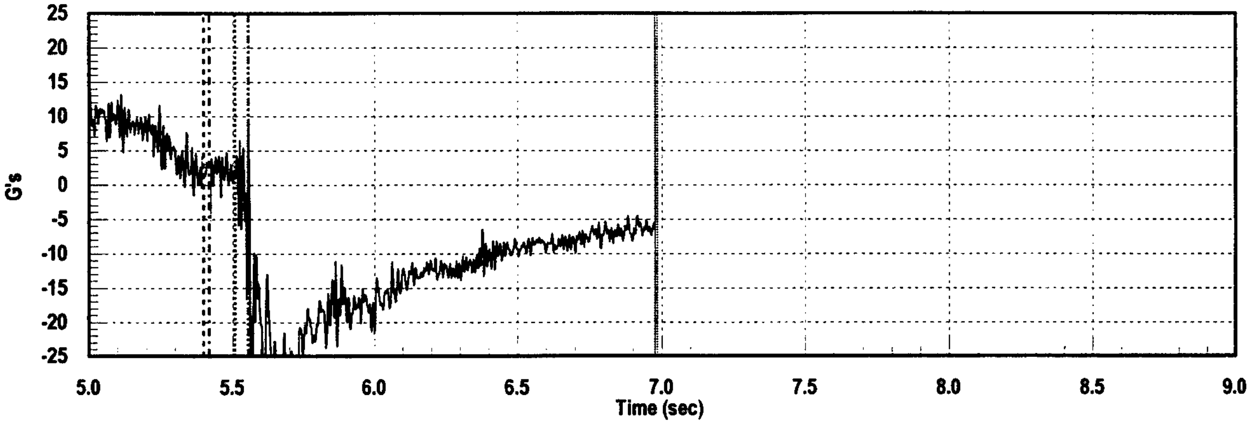
Seat Acceleration CZ



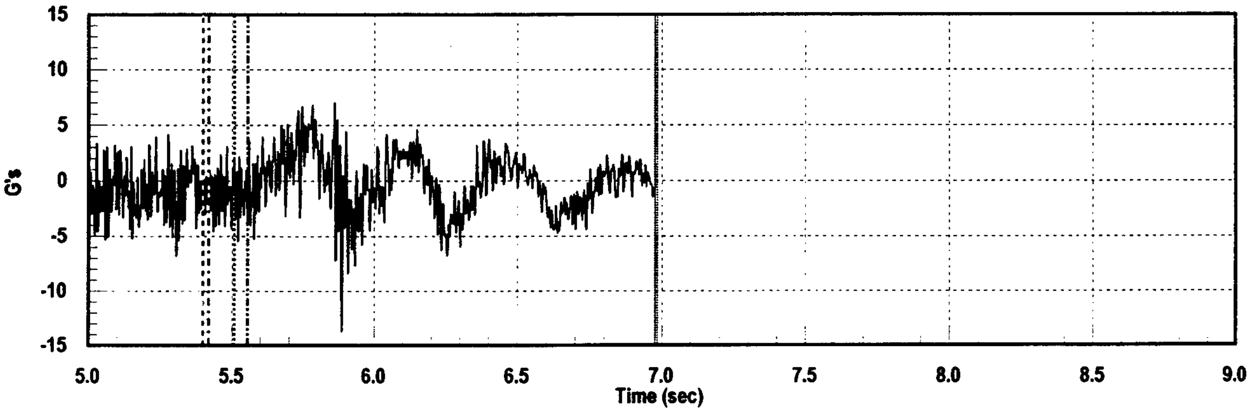
A-3

SL1295, 694 KEAS

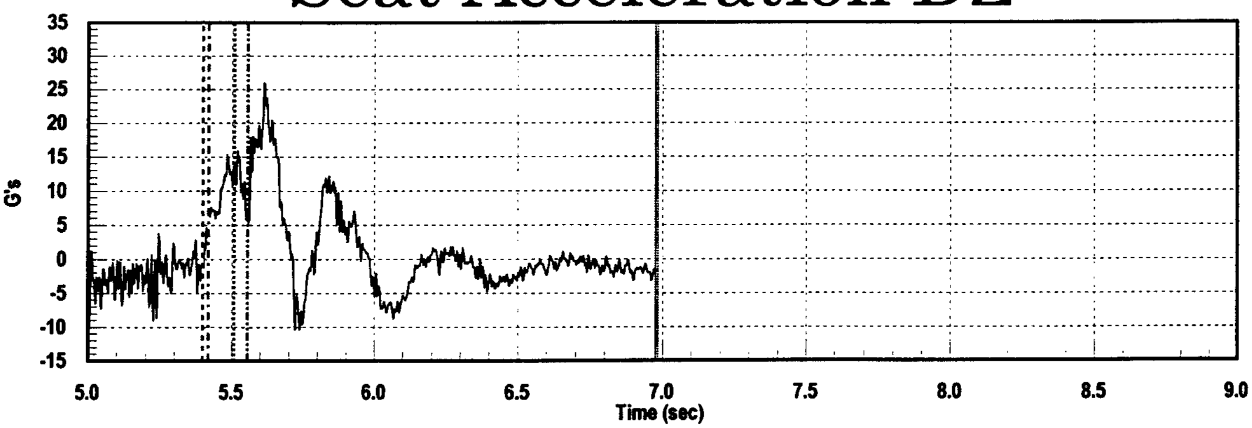
Seat Acceleration DX



Seat Acceleration DY



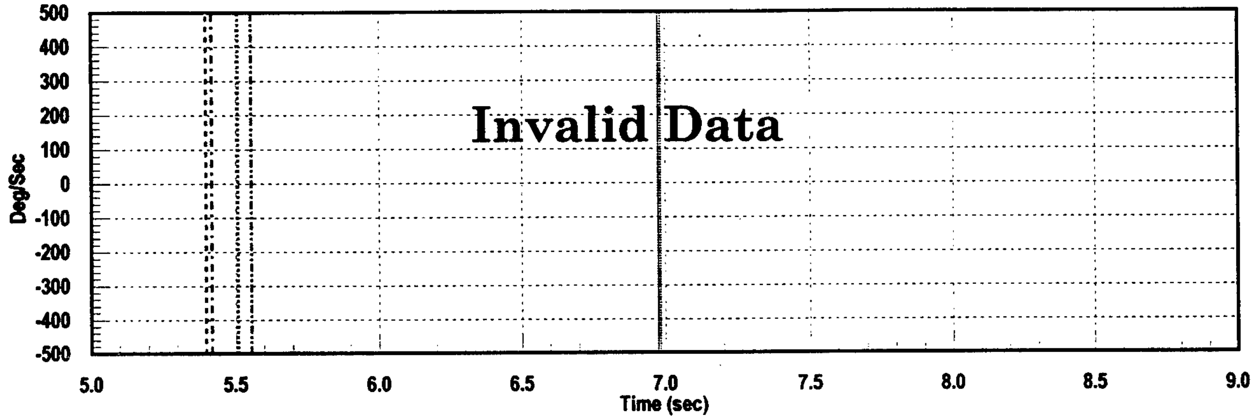
Seat Acceleration DZ



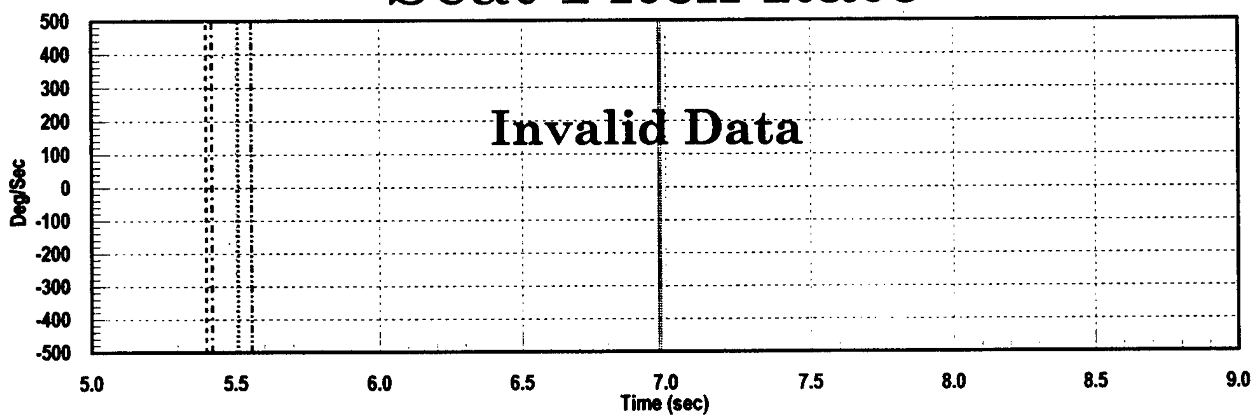
A-4

SL1295, 694 KEAS

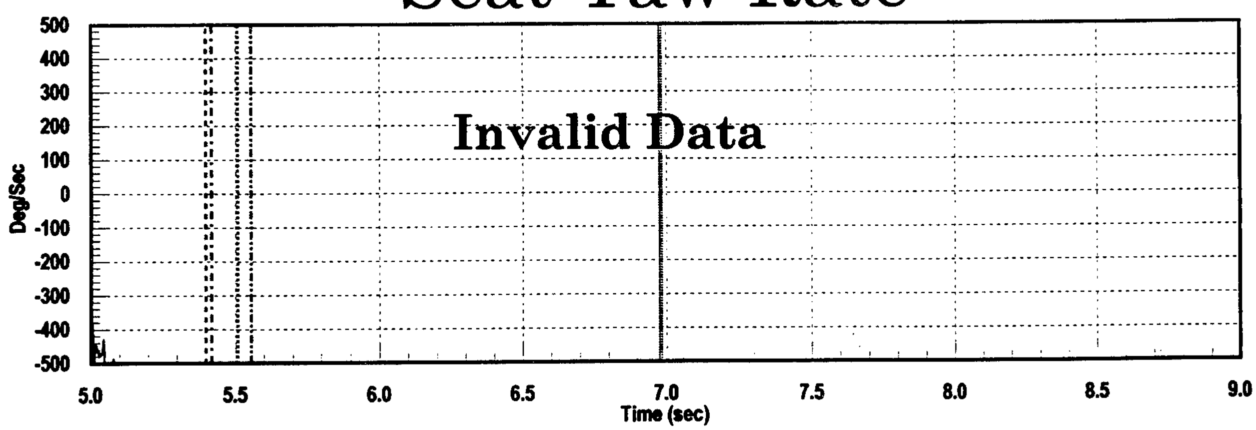
Seat Roll Rate



Seat Pitch Rate

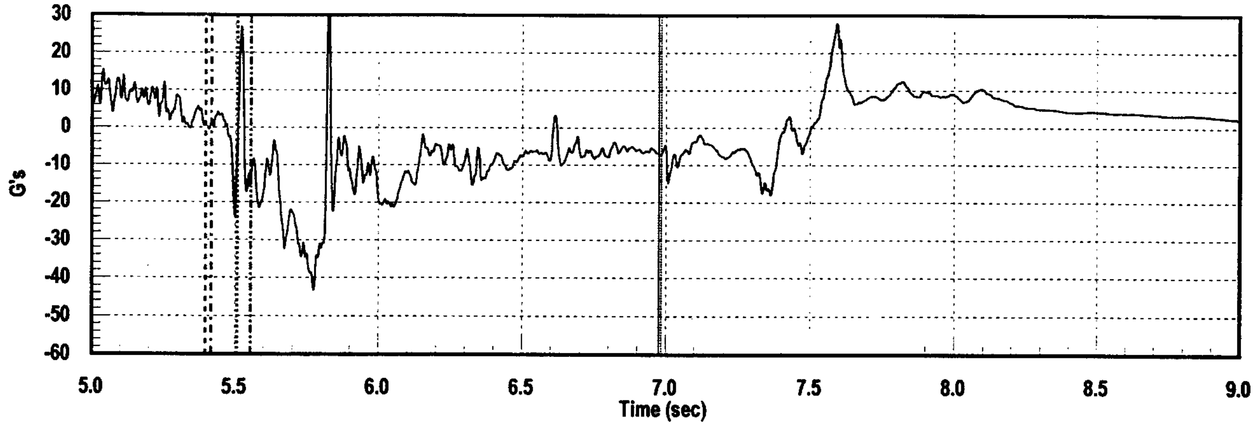


Seat Yaw Rate

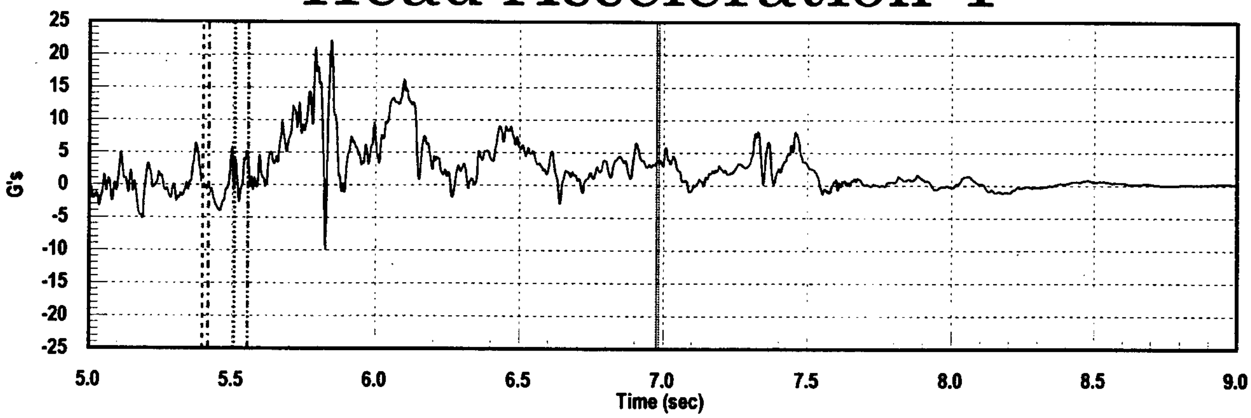


SL1295, 694 KEAS

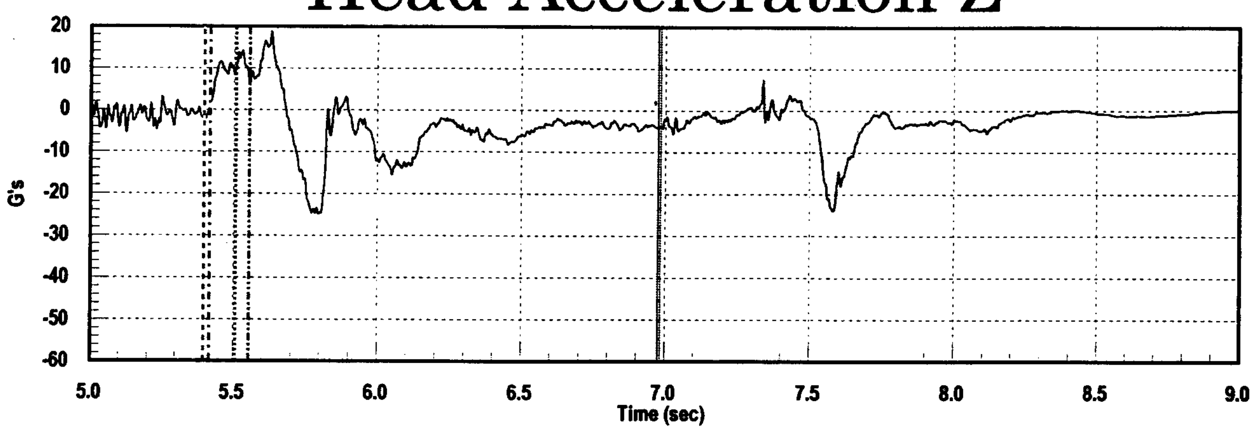
Head Acceleration X



Head Acceleration Y



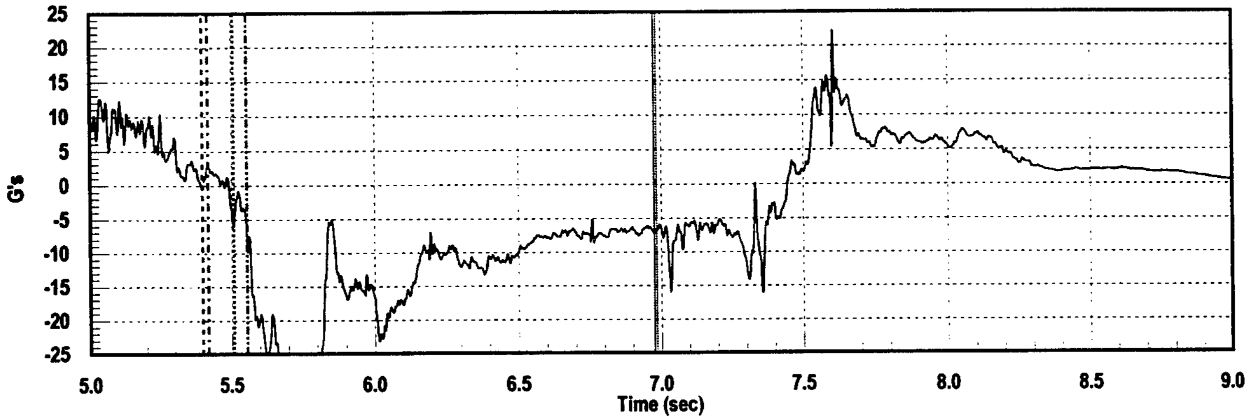
Head Acceleration Z



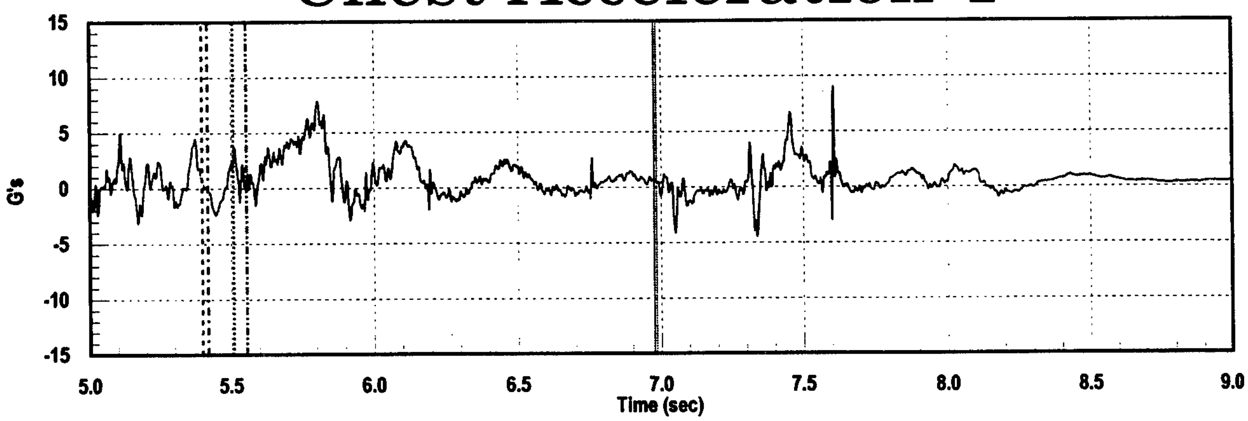
A-6

SL1295, 694 KEAS

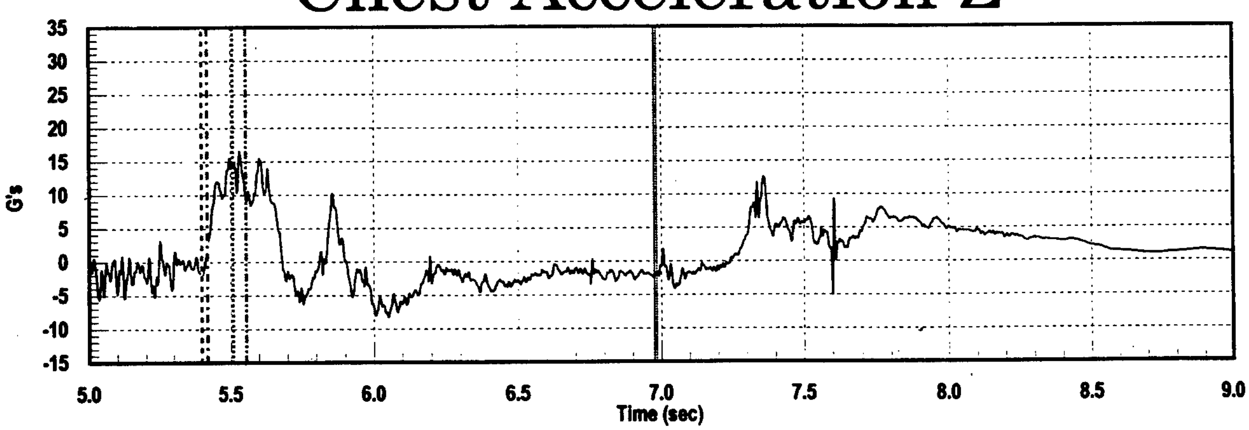
Chest Acceleration X



Chest Acceleration Y



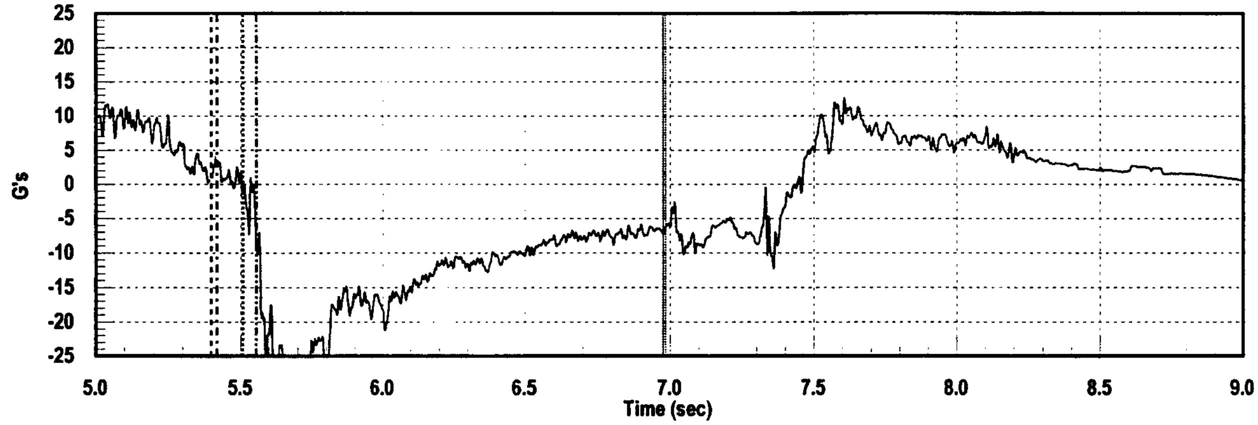
Chest Acceleration Z



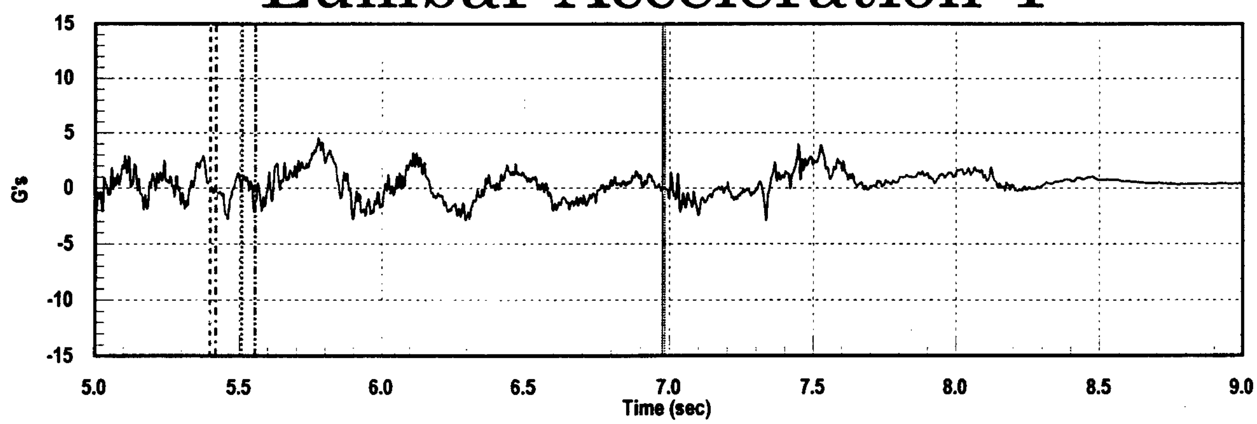
A-7

SL1295, 694 KEAS

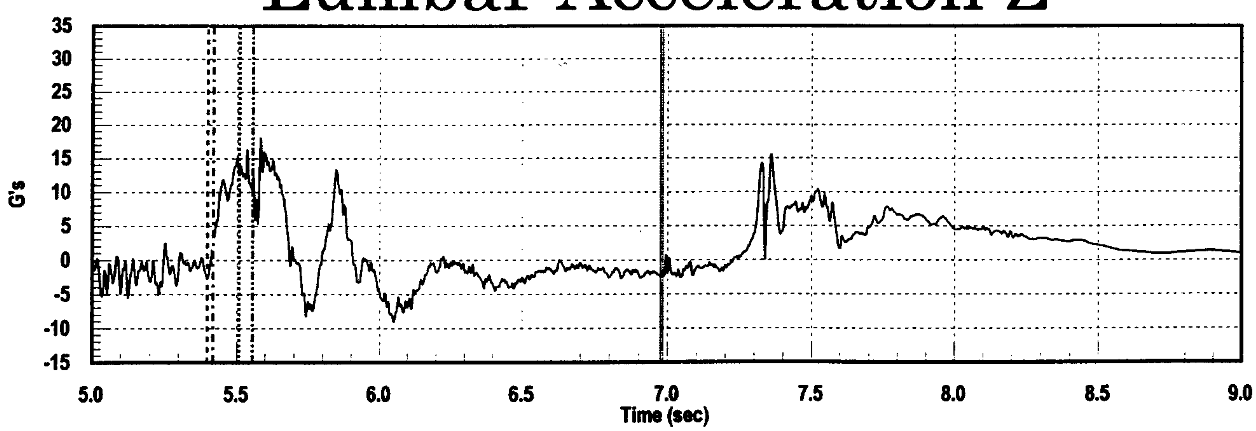
Lumbar Acceleration X



Lumbar Acceleration Y



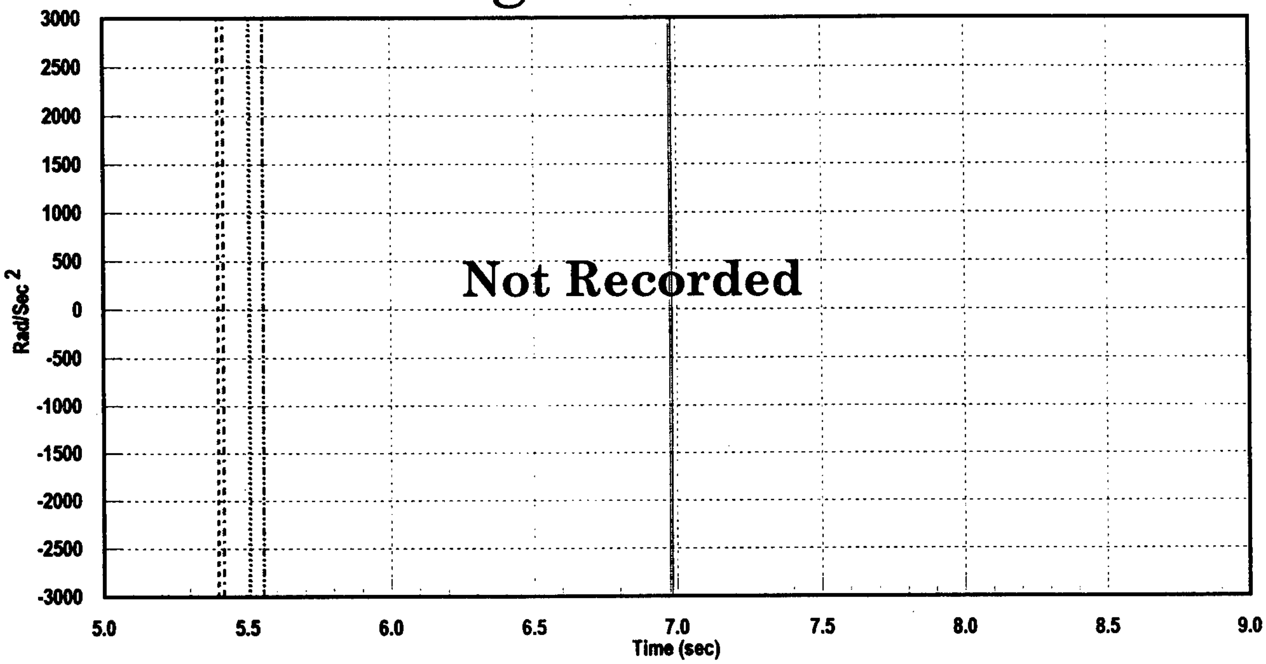
Lumbar Acceleration Z



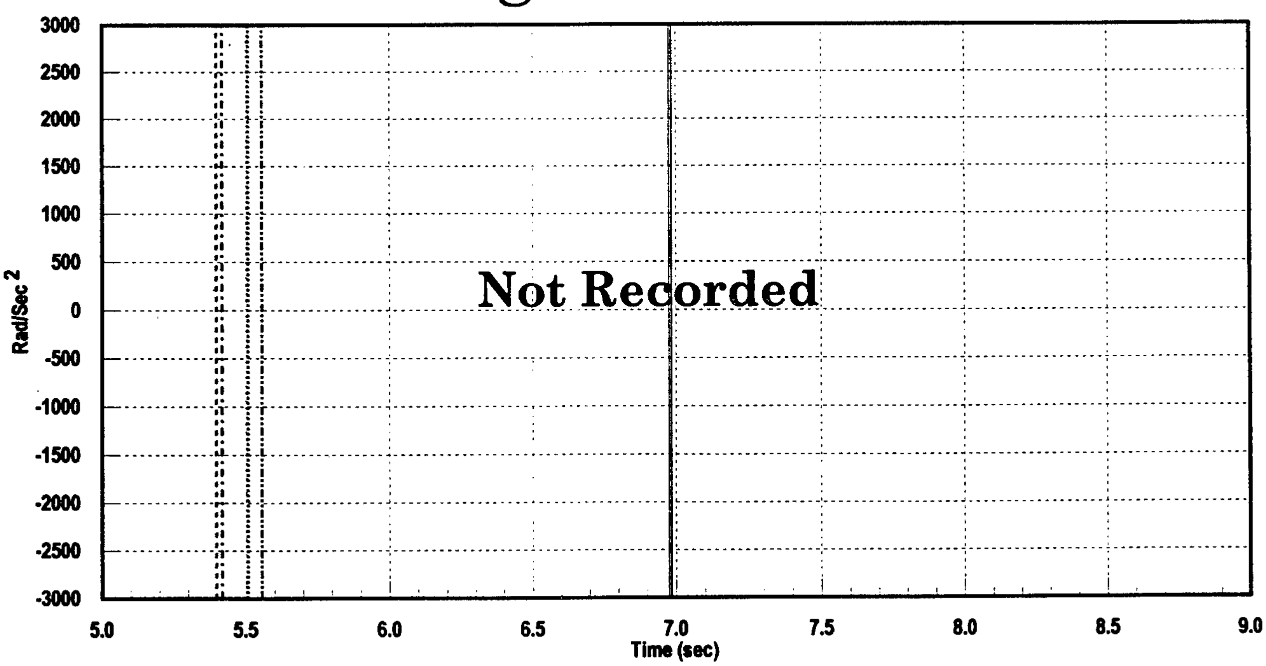
A-8

SL1295, 694 KEAS

Head Angular Acceleration Y



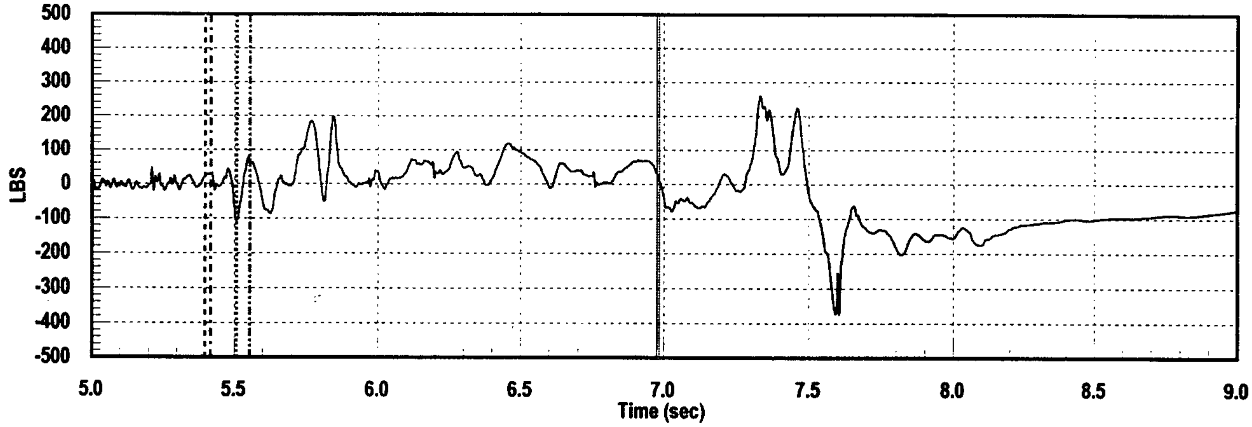
Chest Angular Acceleration Y



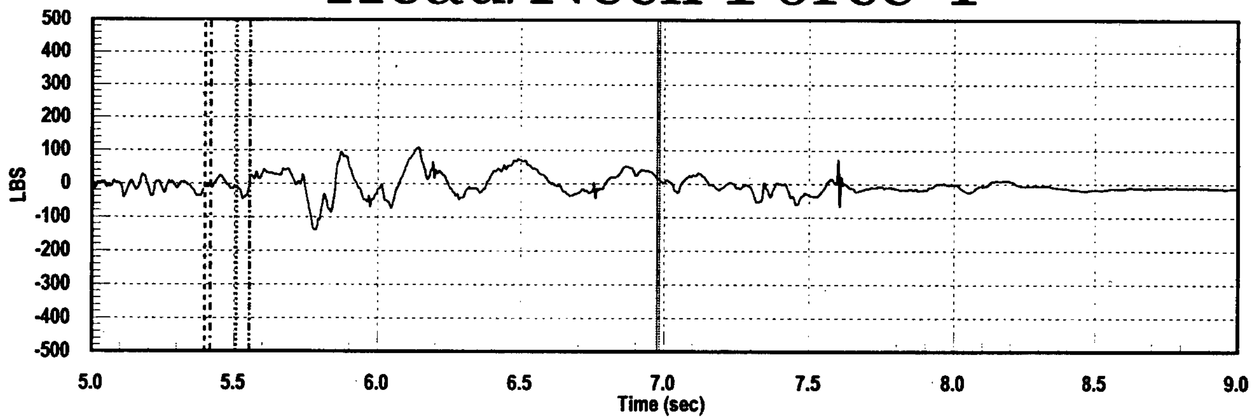
A-9

SL1295, 694 KEAS

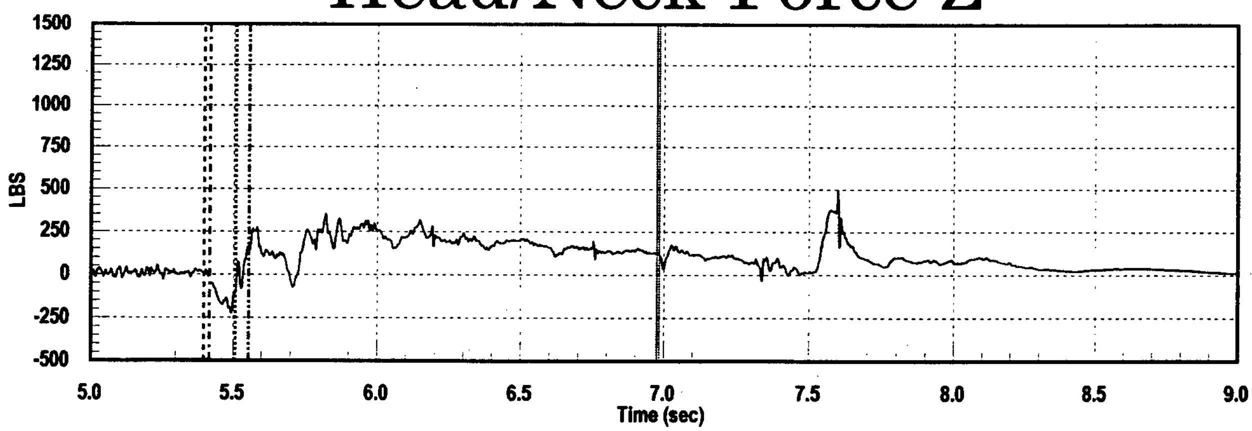
Head/Neck Force X



Head/Neck Force Y



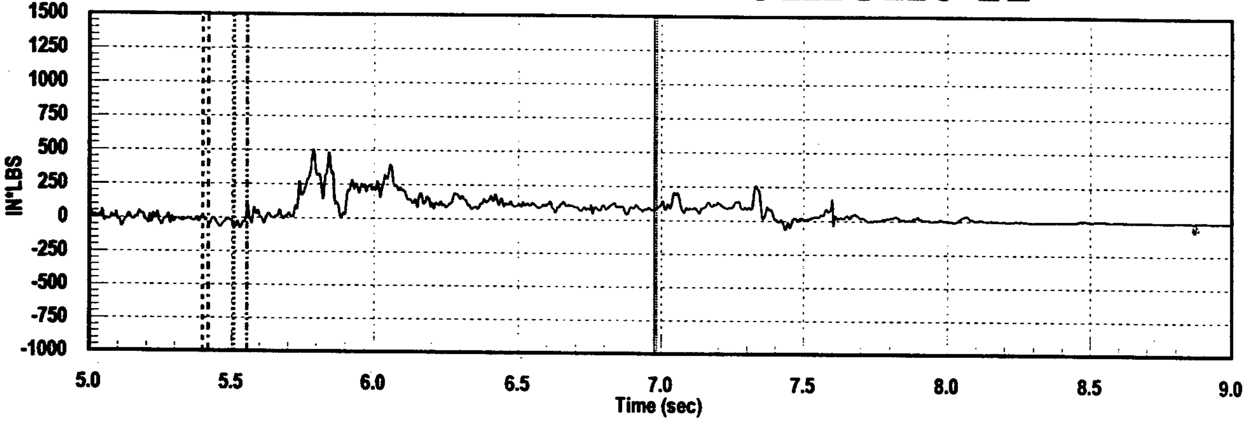
Head/Neck Force Z



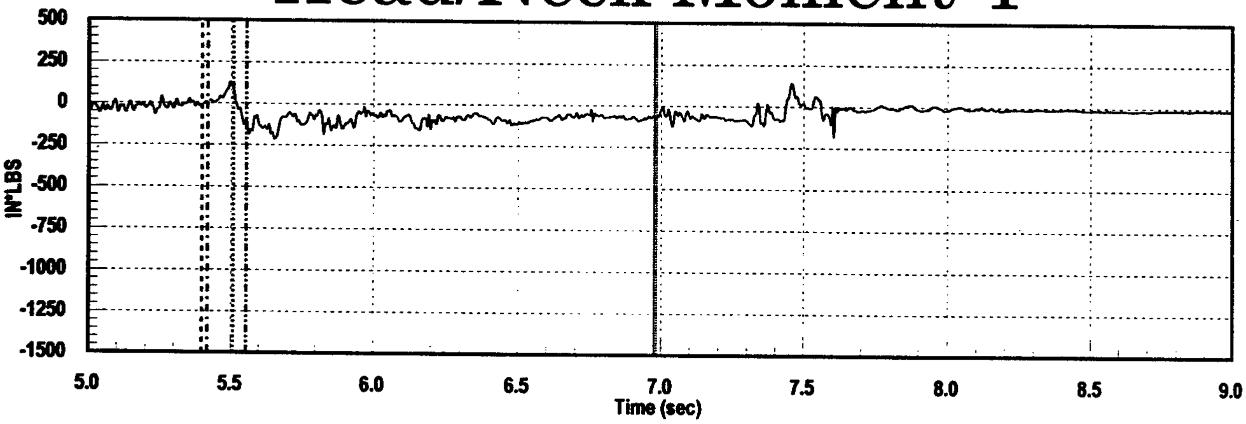
A-10

SL1295, 694 KEAS

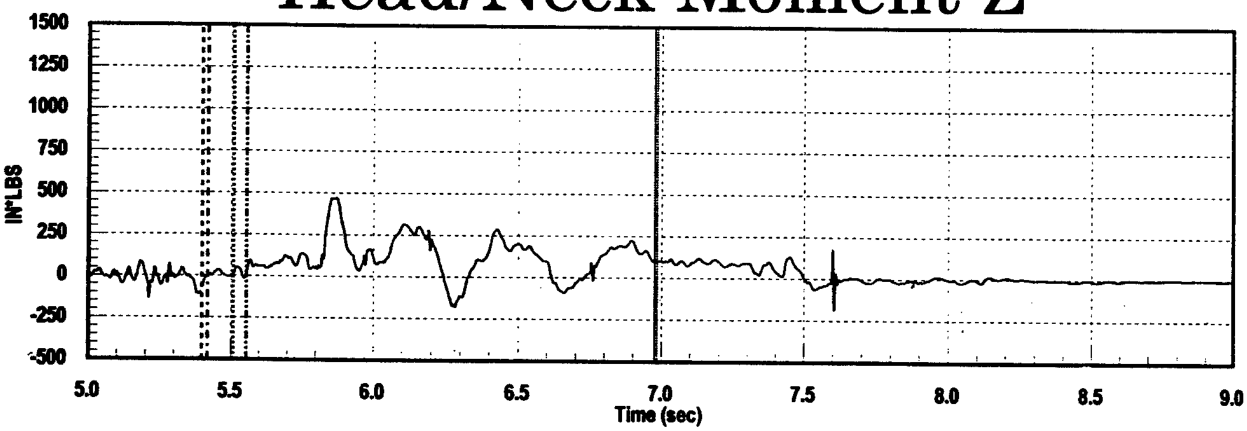
Head/Neck Moment X



Head/Neck Moment Y



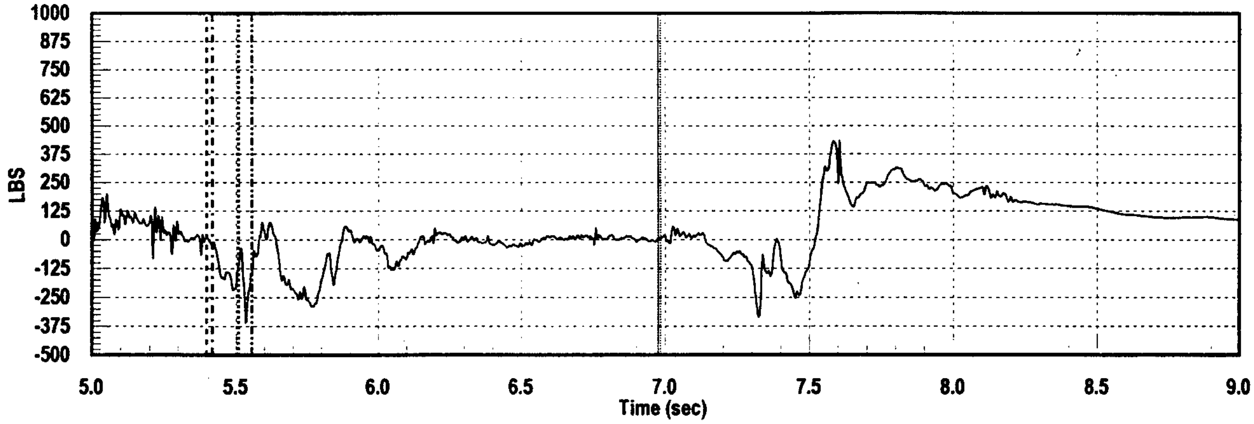
Head/Neck Moment Z



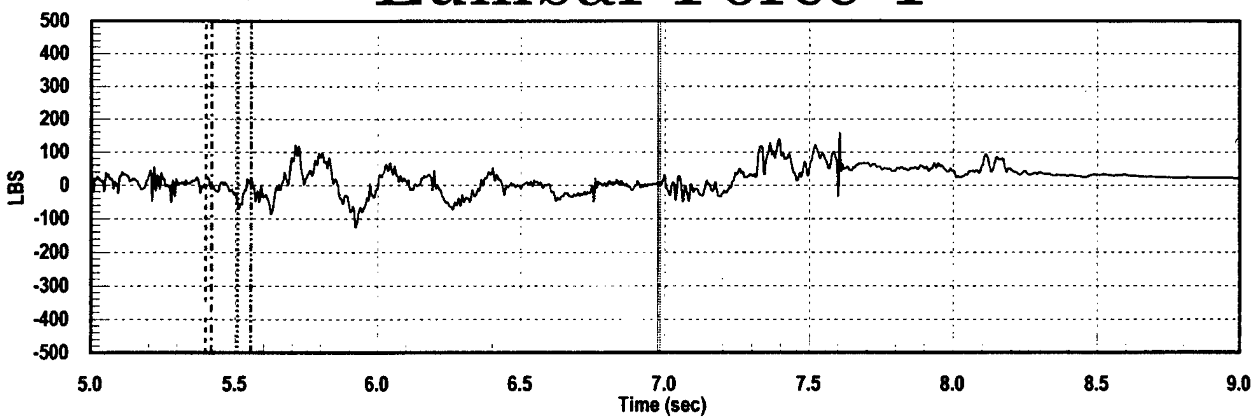
A-11

SL1295, 694 KEAS

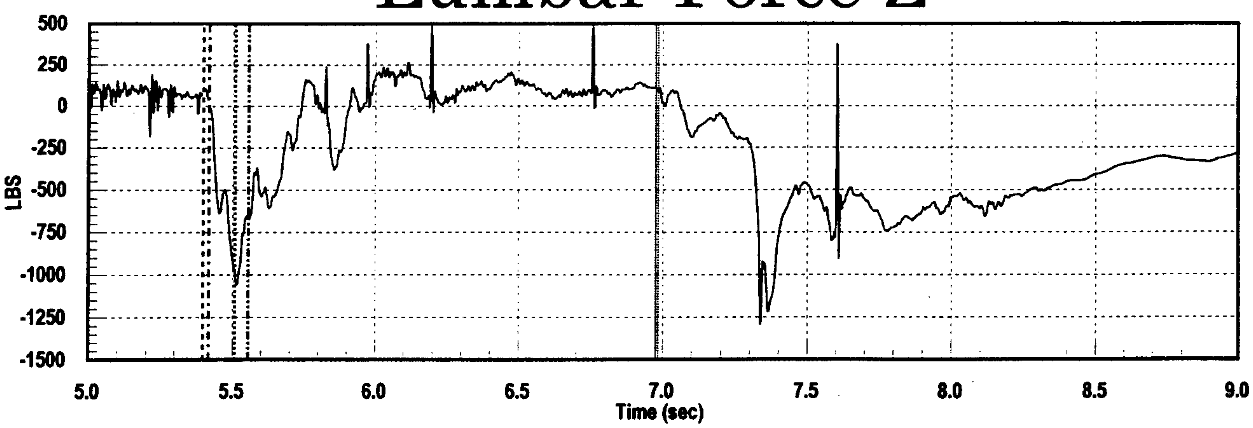
Lumbar Force X



Lumbar Force Y



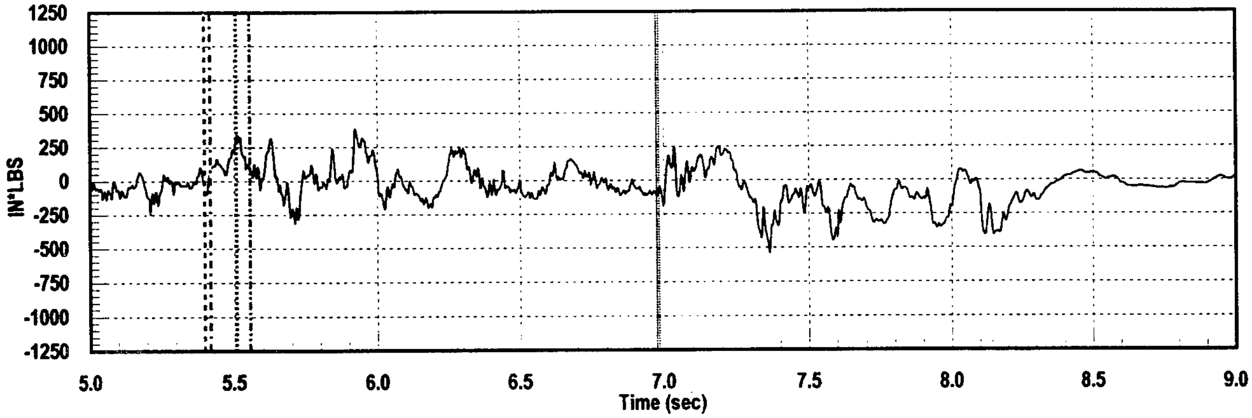
Lumbar Force Z



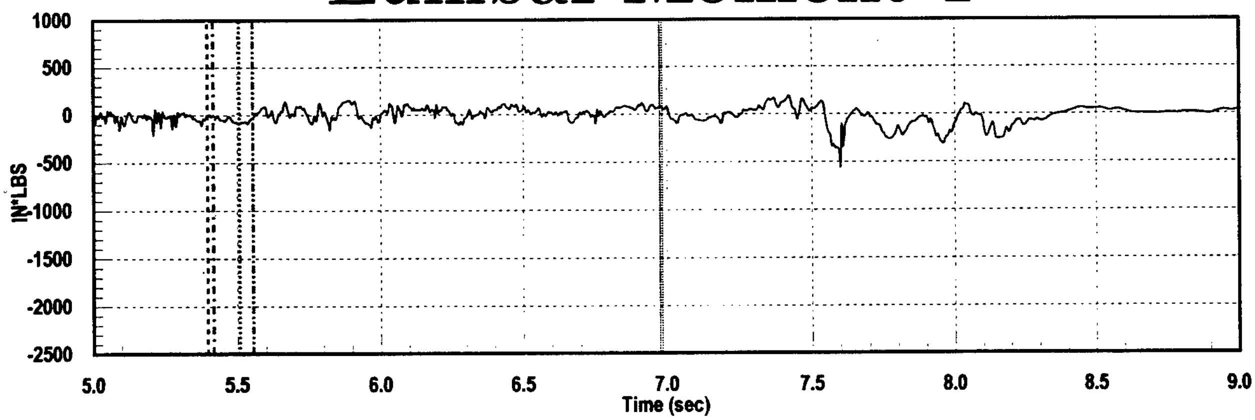
A-12

SL1295, 694 KEAS

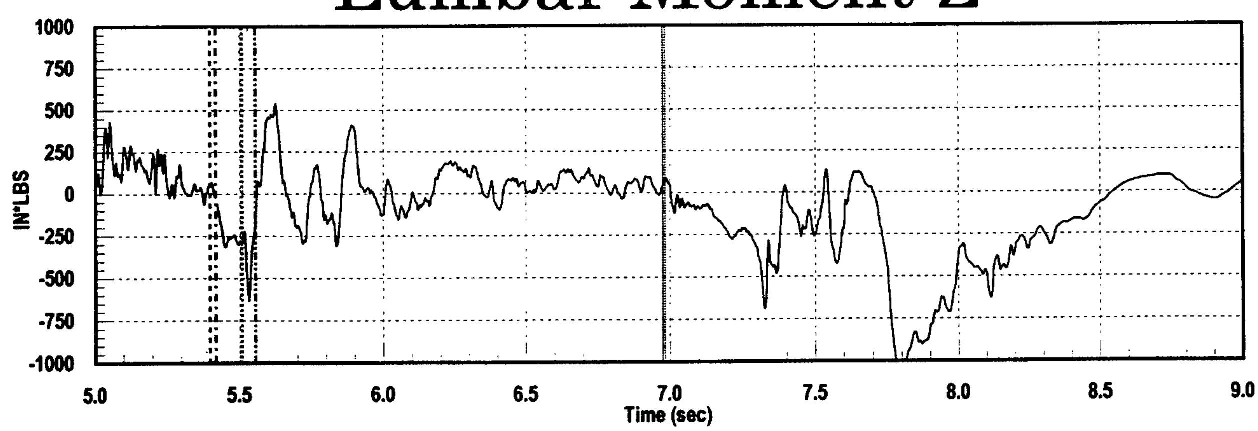
Lumbar Moment X



Lumbar Moment Y



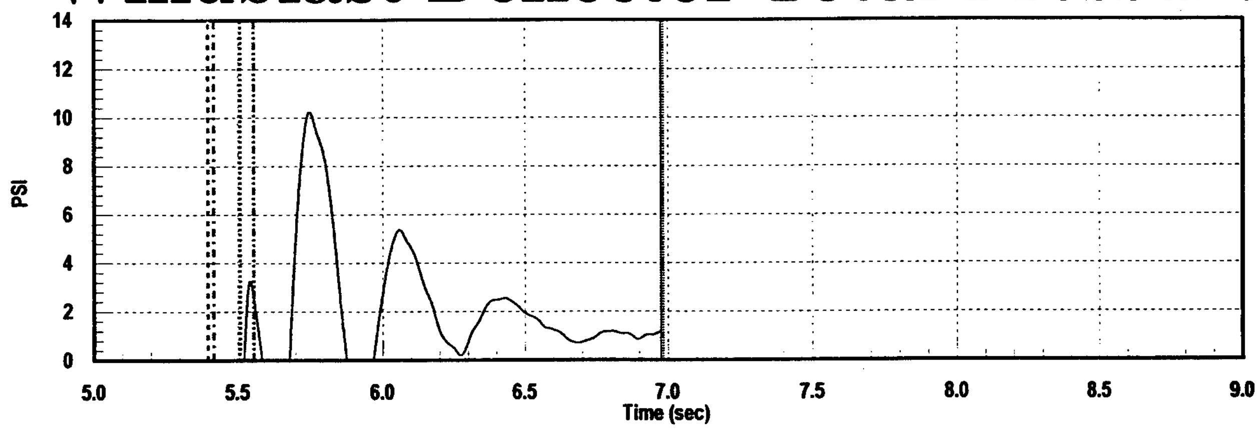
Lumbar Moment Z



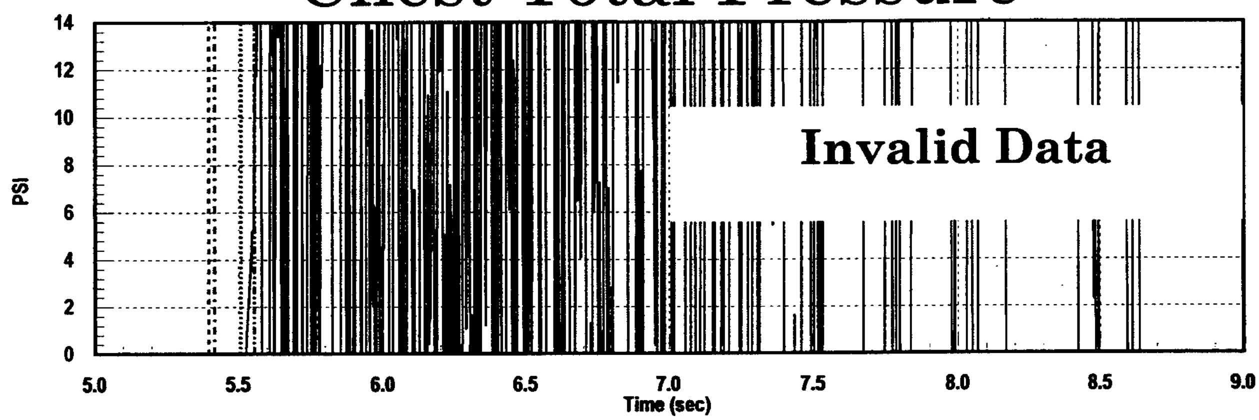
A-13

SL1295, 694 KEAS

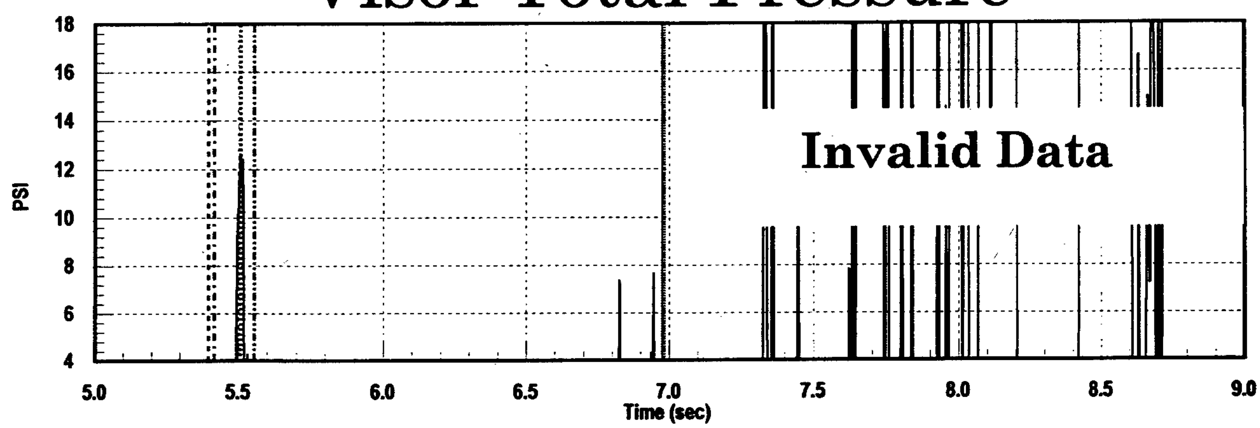
Windblast Deflector Total Pressure



Chest Total Pressure



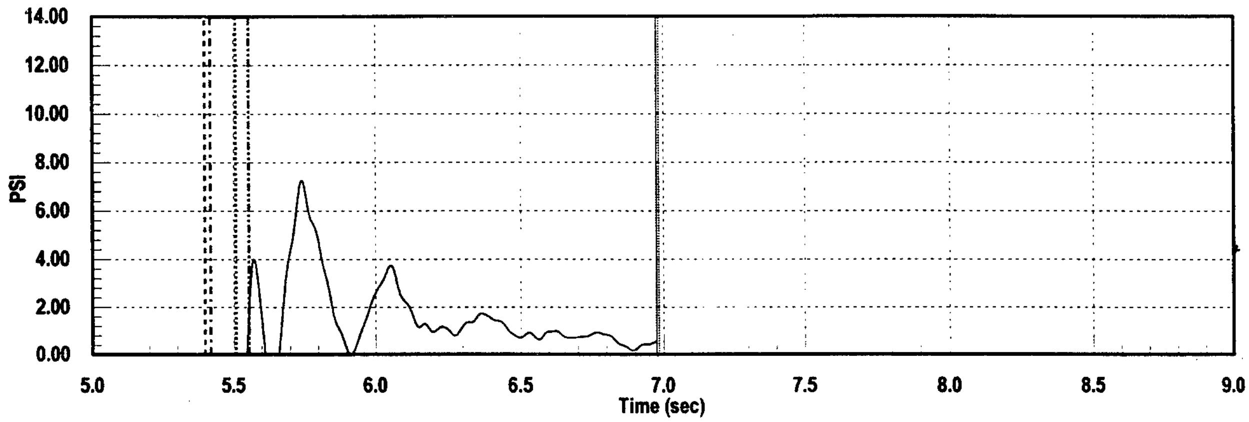
Visor Total Pressure



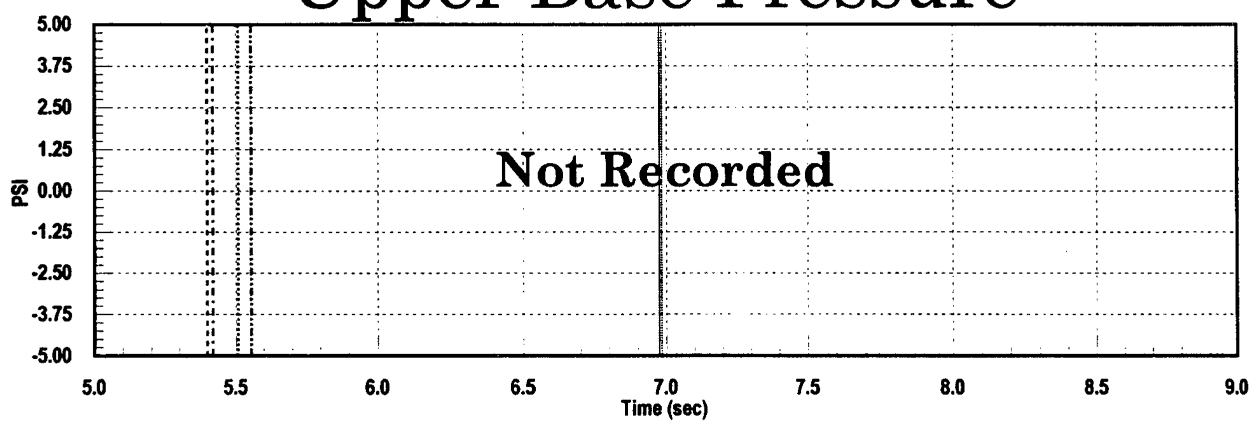
A-14

SL1295, 694 KEAS

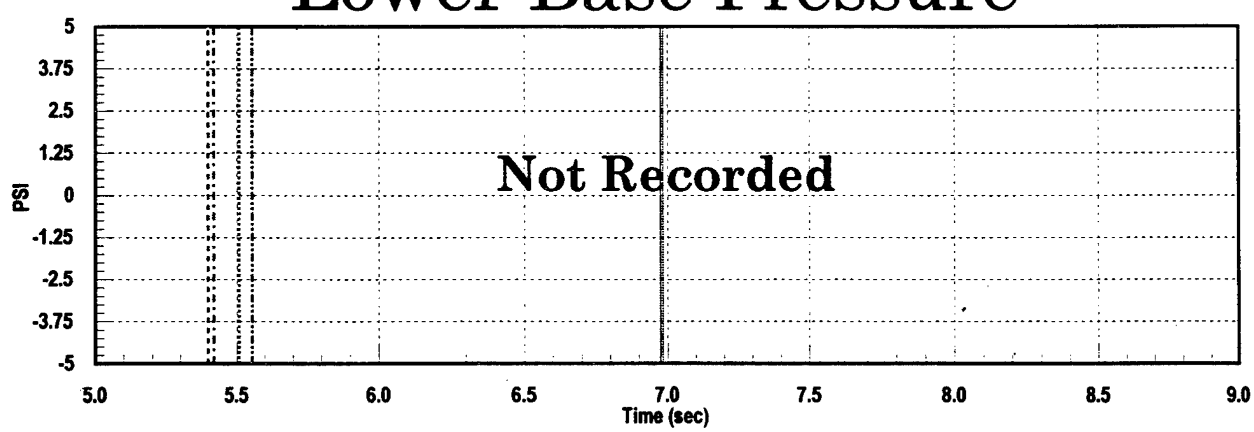
Windblast Deflector Static Pressure



Upper Base Pressure



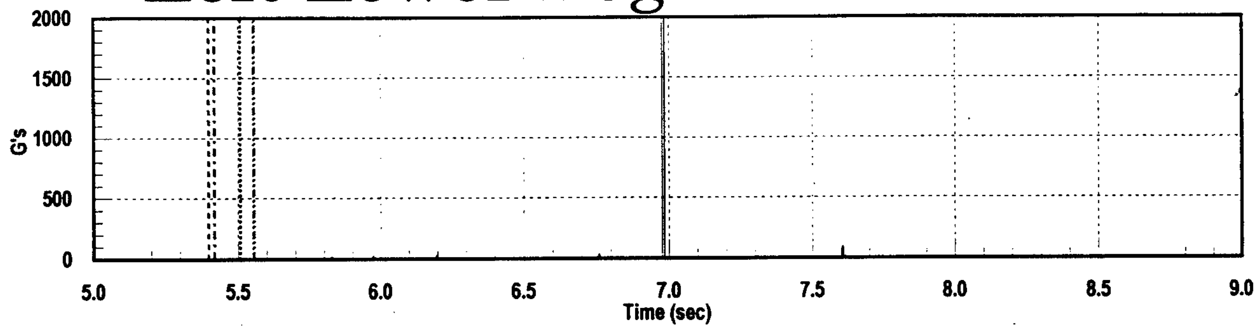
Lower Base Pressure



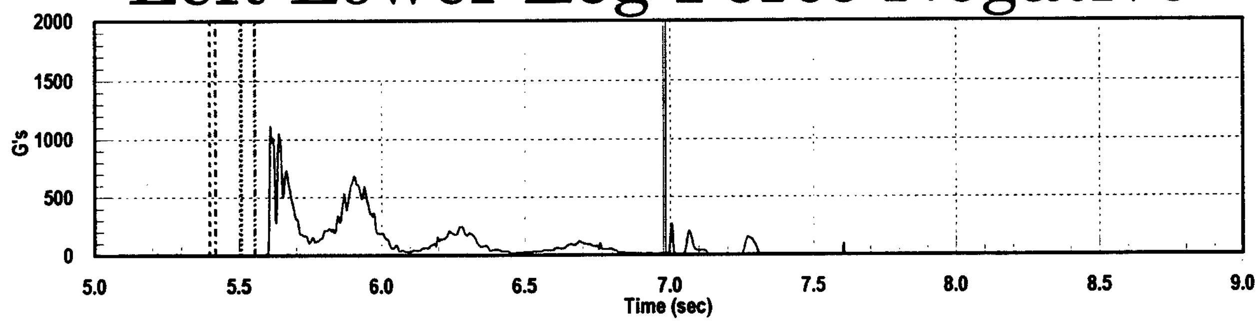
A-15

SL1295, 694 KEAS

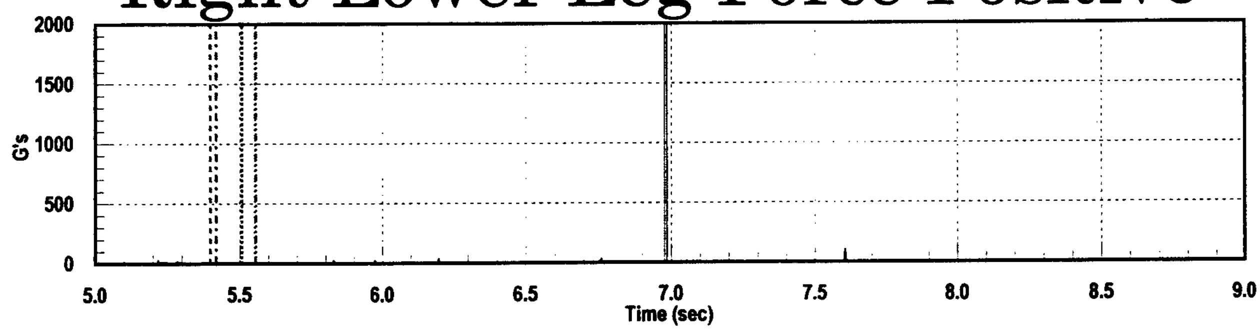
Left Lower Leg Force Positive



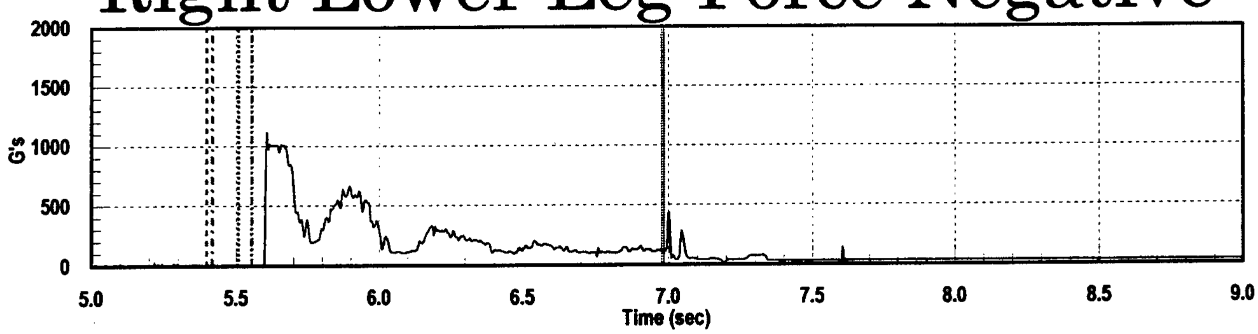
Left Lower Leg Force Negative



Right Lower Leg Force Positive



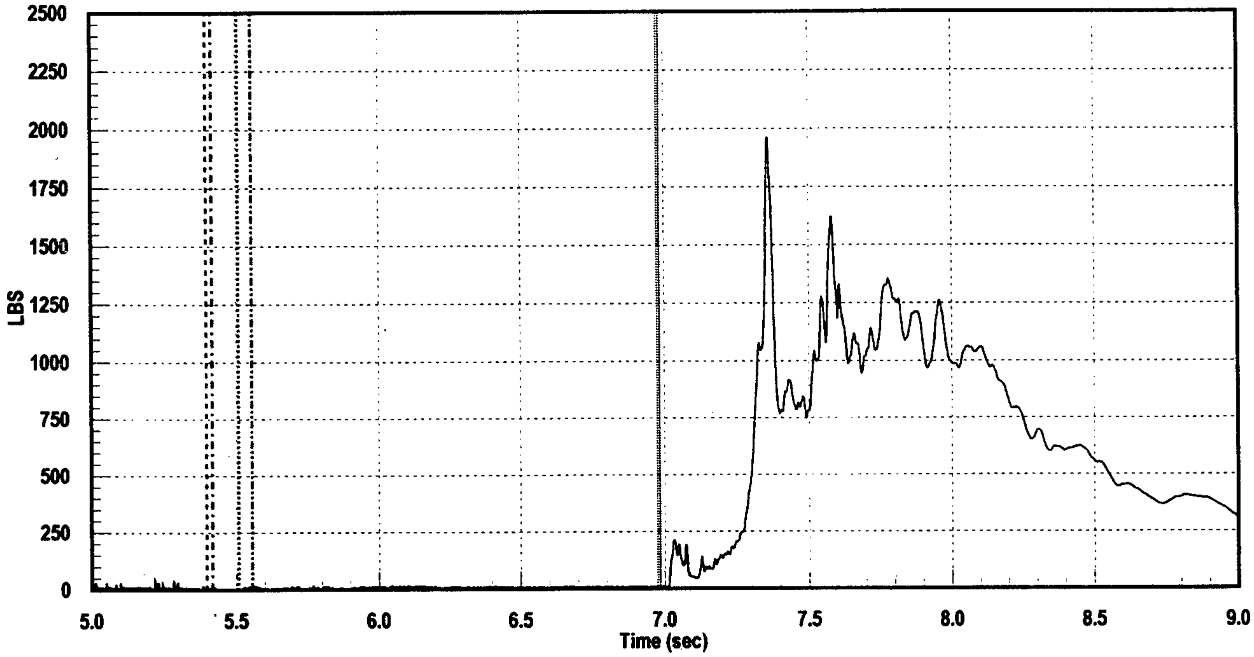
Right Lower Leg Force Negative



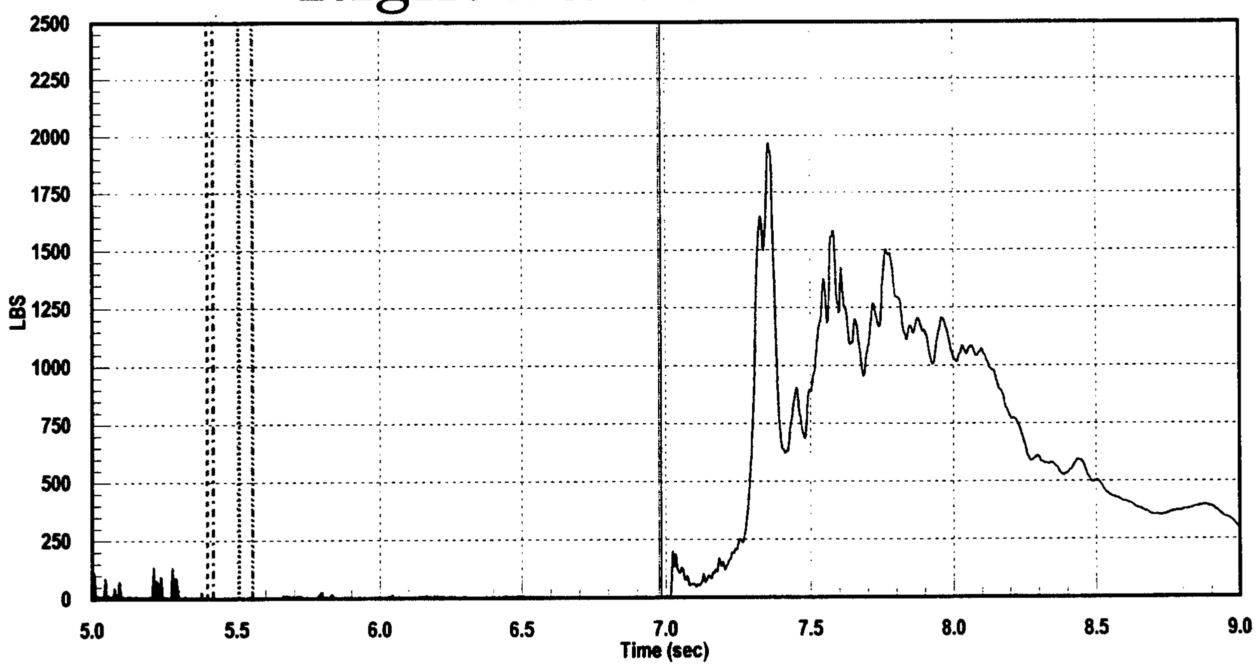
A-16

SL1295, 694 KEAS

Left Parachute Riser



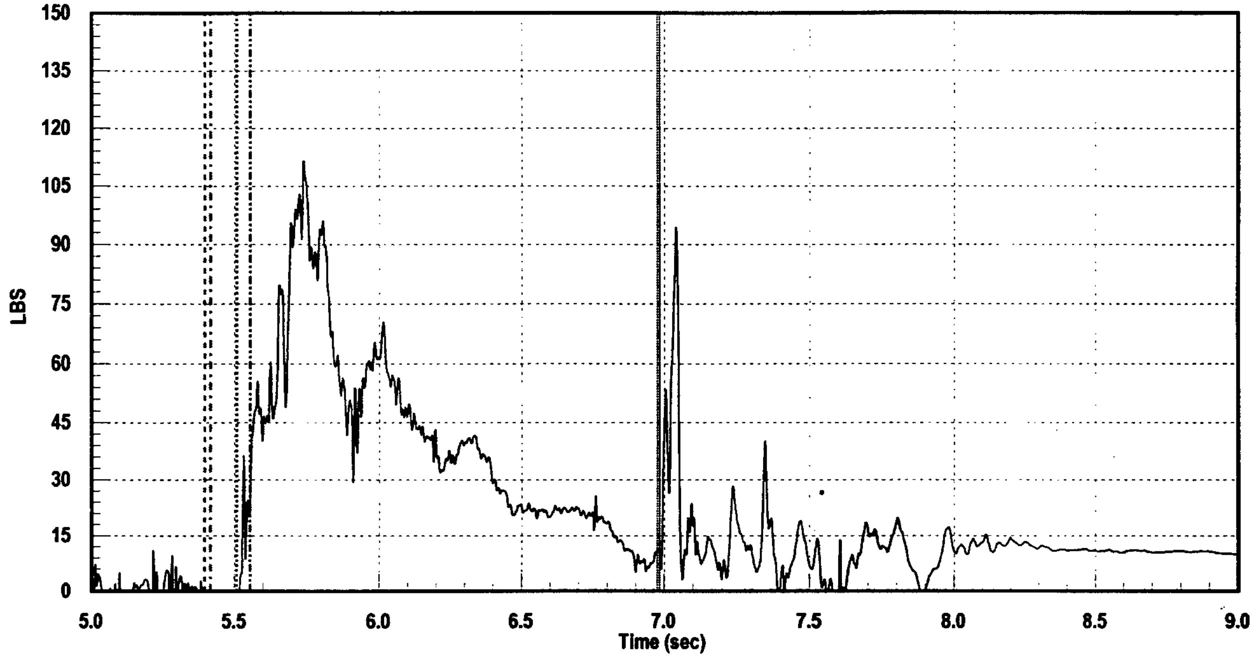
Right Parachute Riser



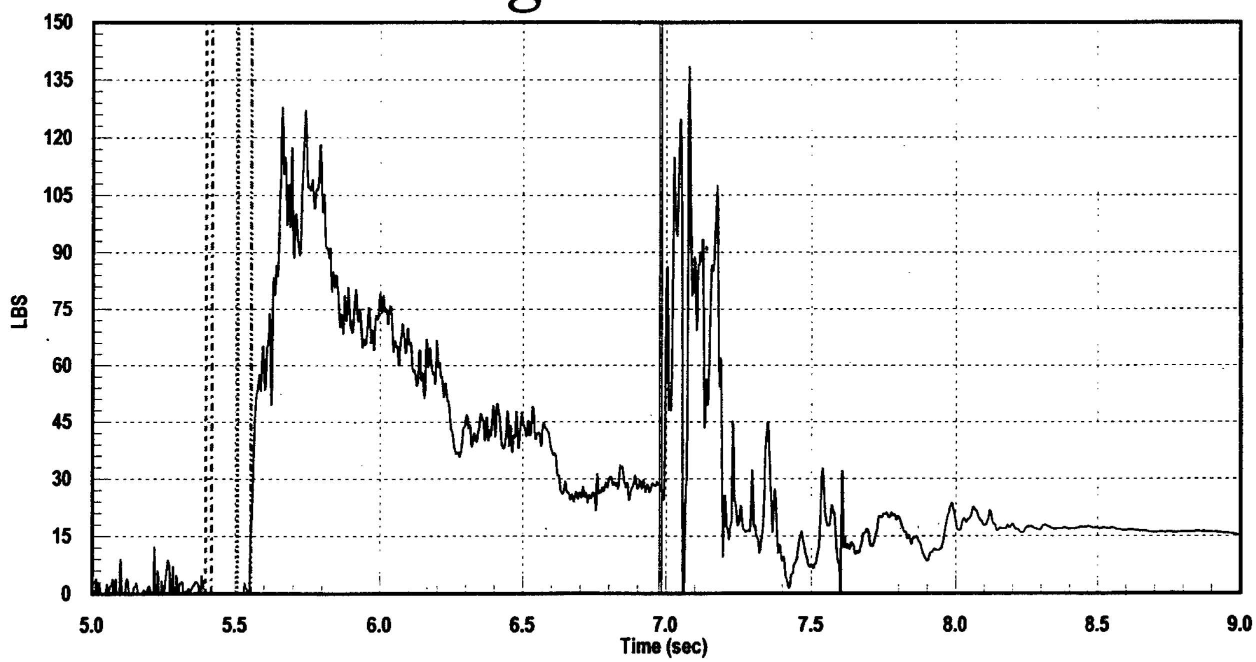
A-17

SL1295, 694 KEAS

Left Arm Lift

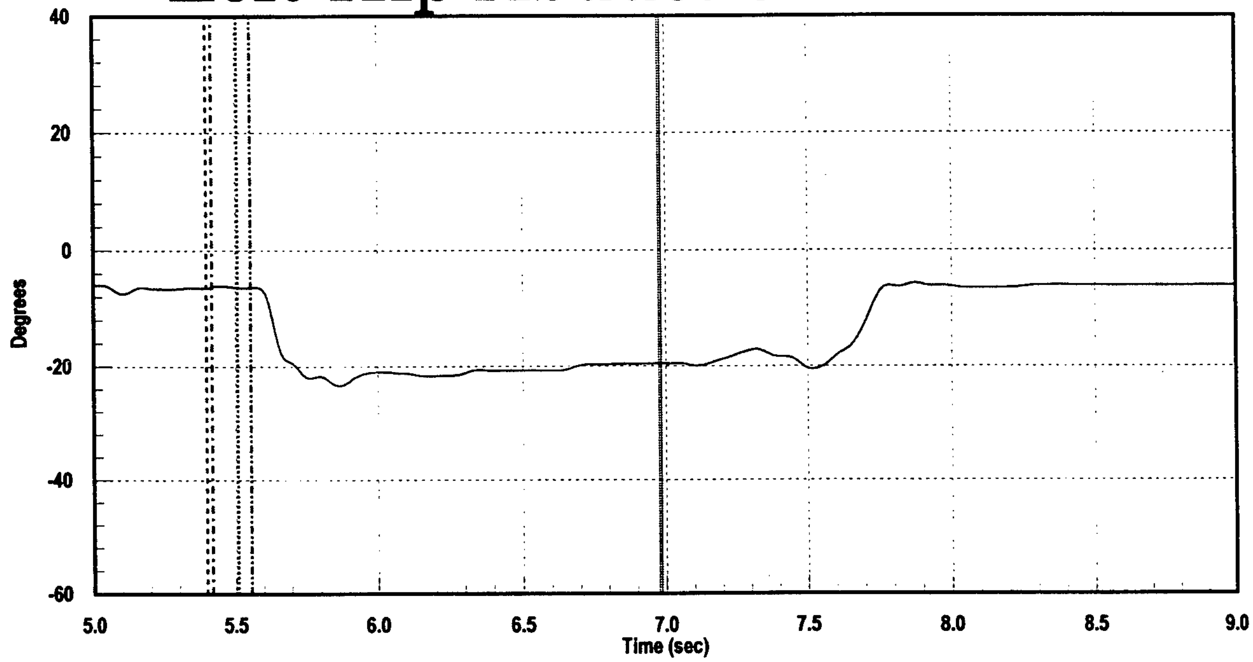


Right Arm Lift

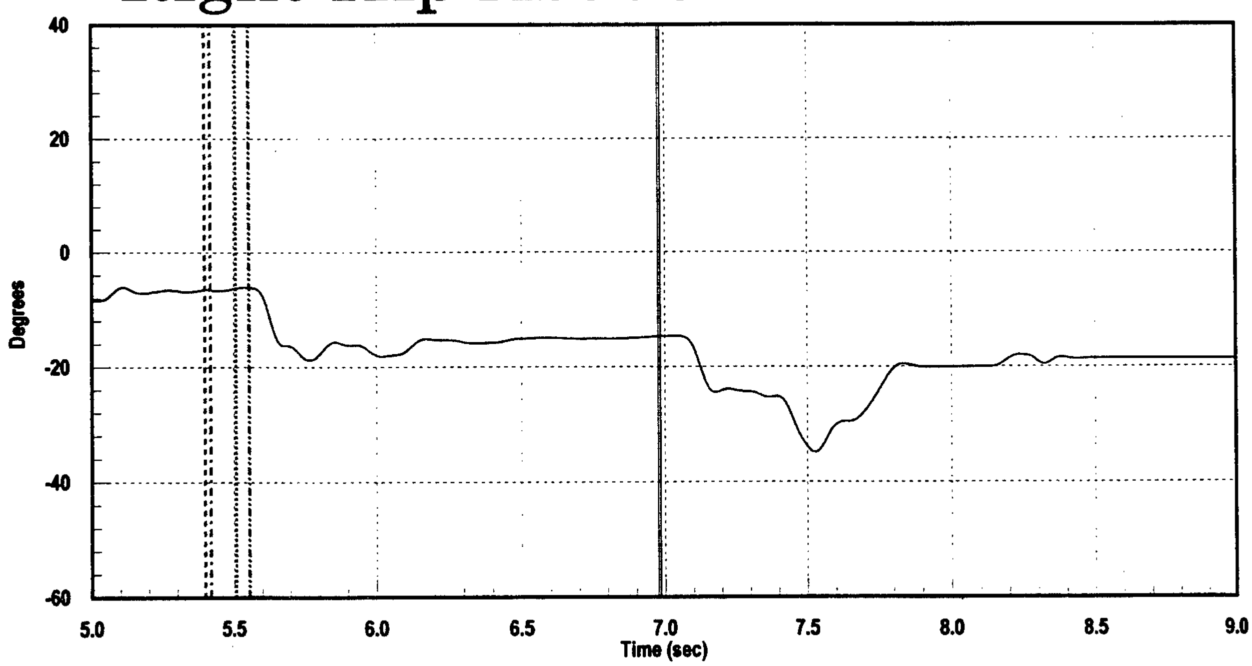


SL1295, 694 KEAS

Left Hip Abduction/Adduction



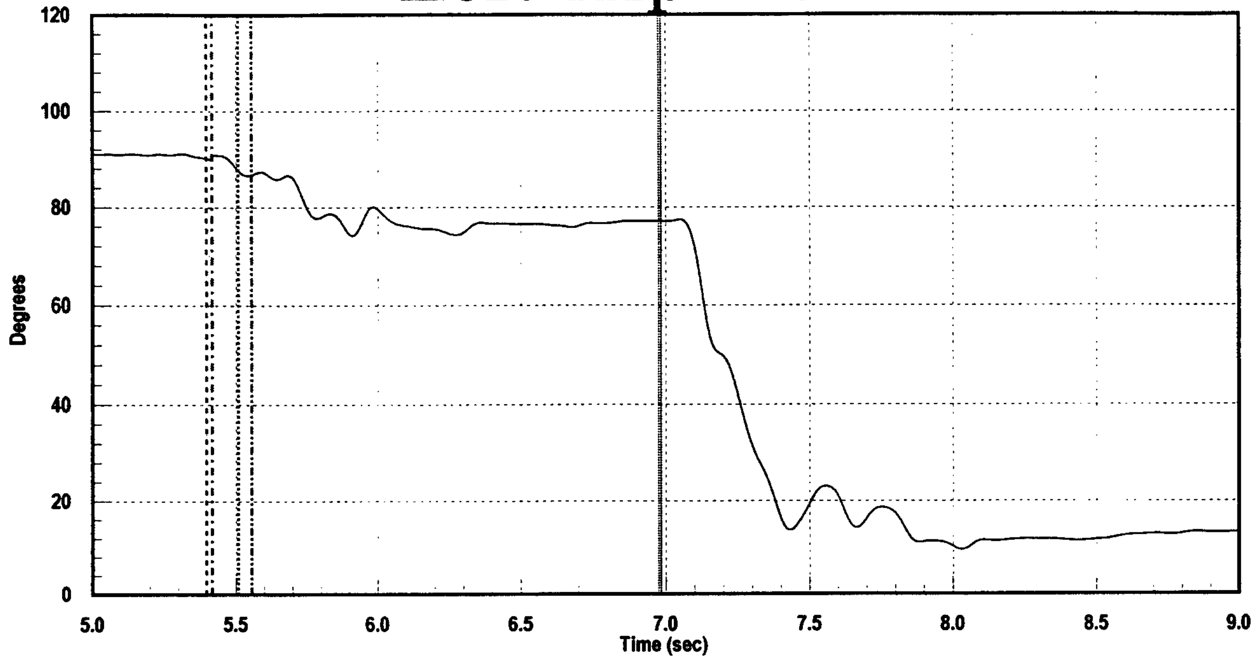
Right Hip Abduction/Adduction



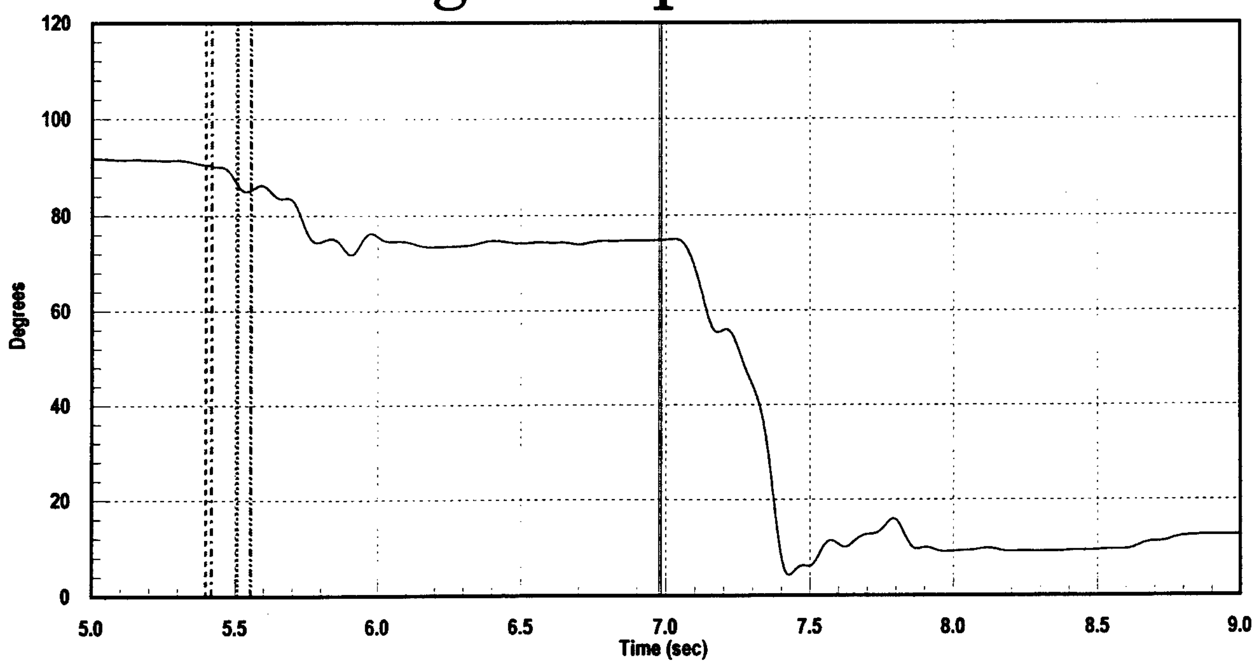
A-19

SL1295, 694 KEAS

Left Hip Flexion



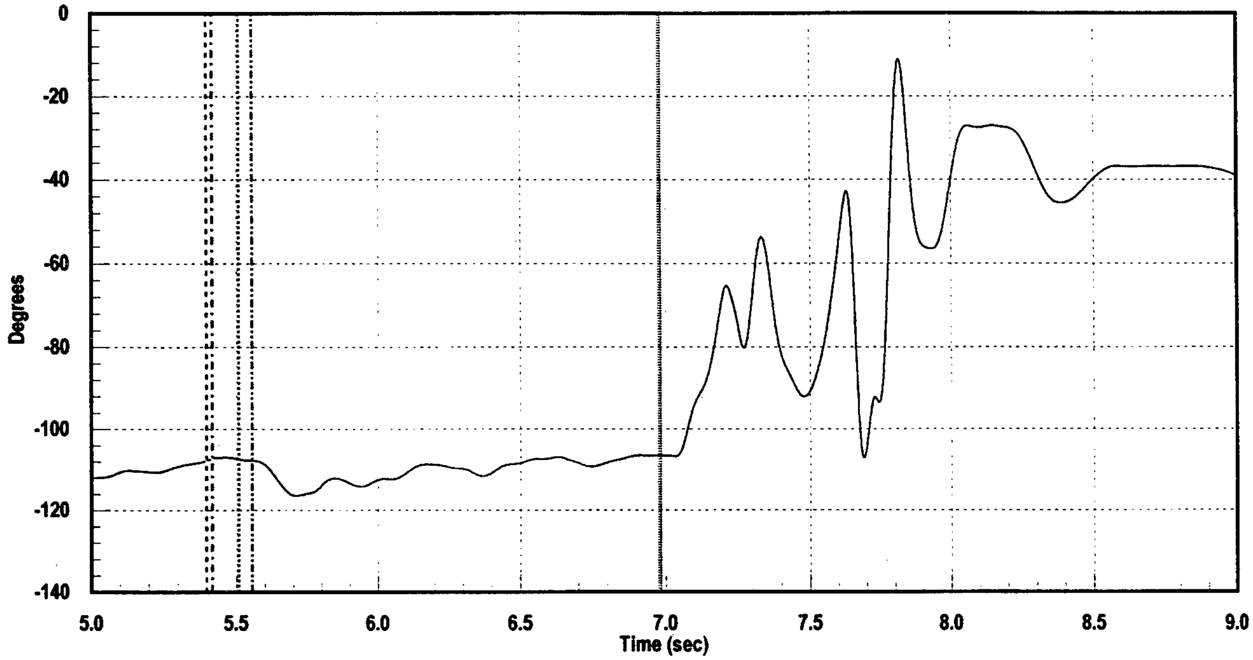
Right Hip Flexion



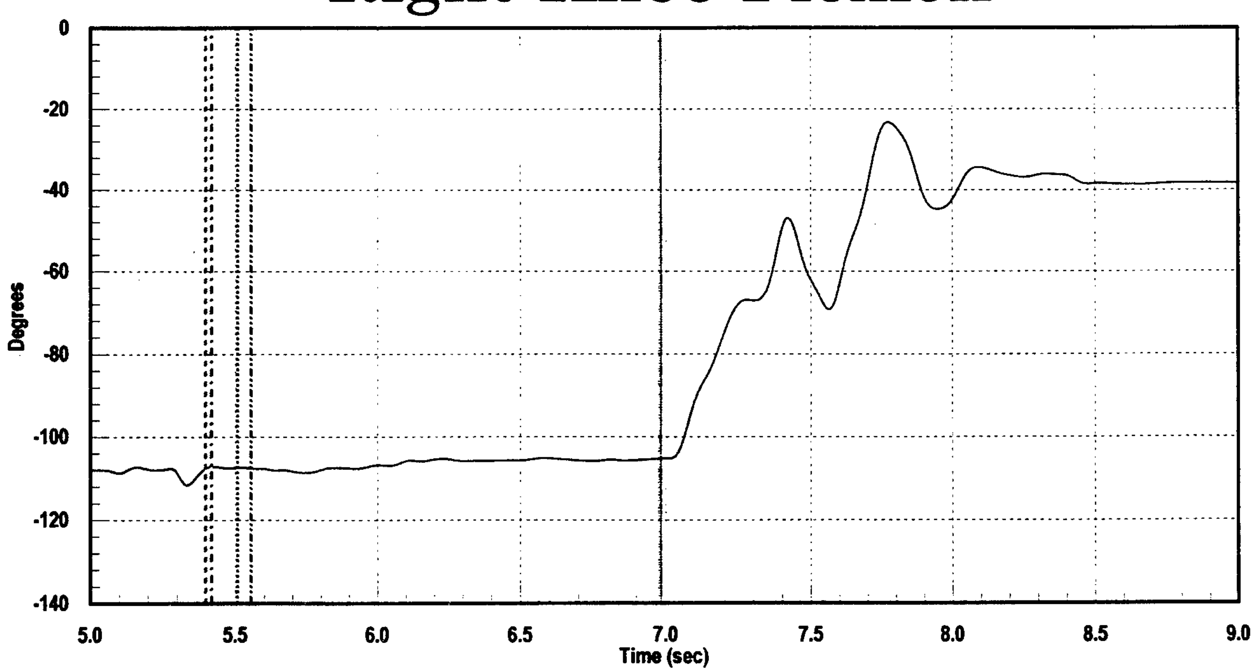
A-20

SL1295, 694 KEAS

Left Knee Flexion



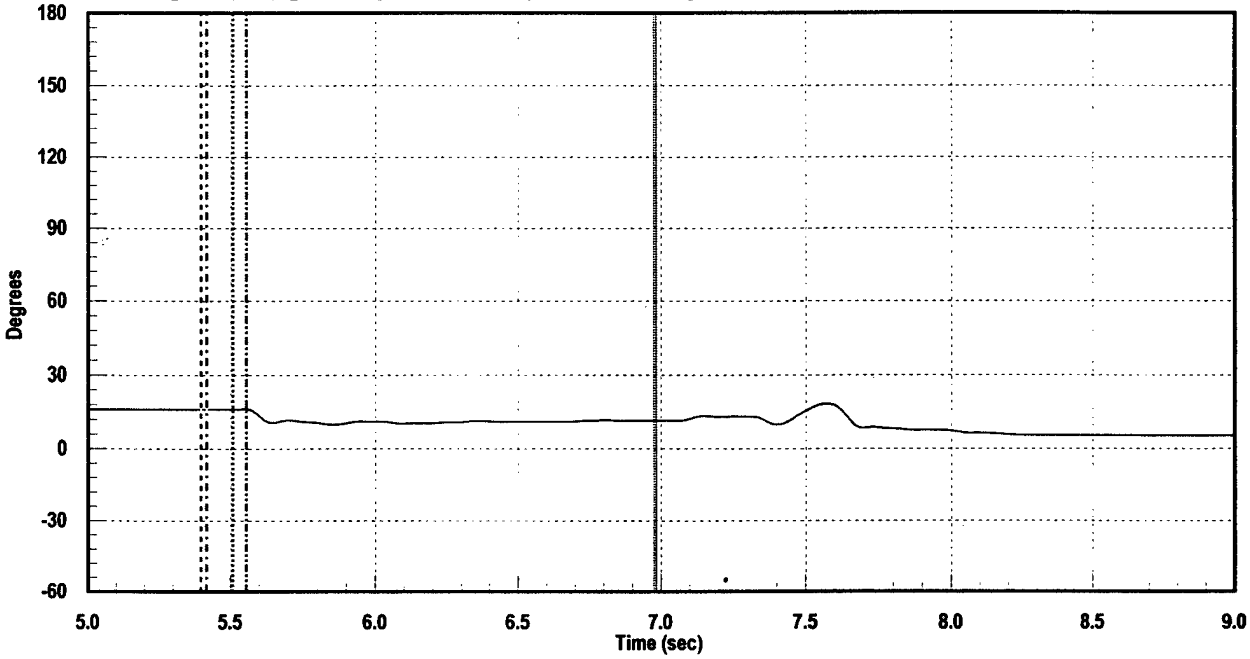
Right Knee Flexion



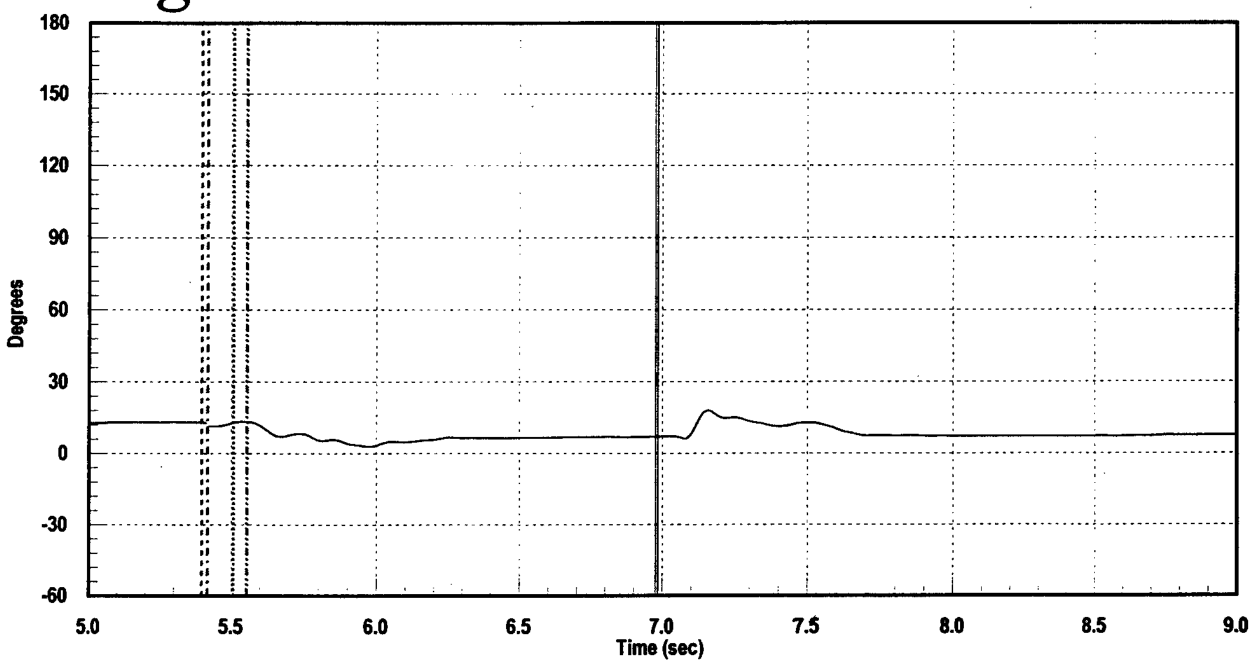
A-21

SL1295, 694 KEAS

Left Shoulder Flexion/Extenstion



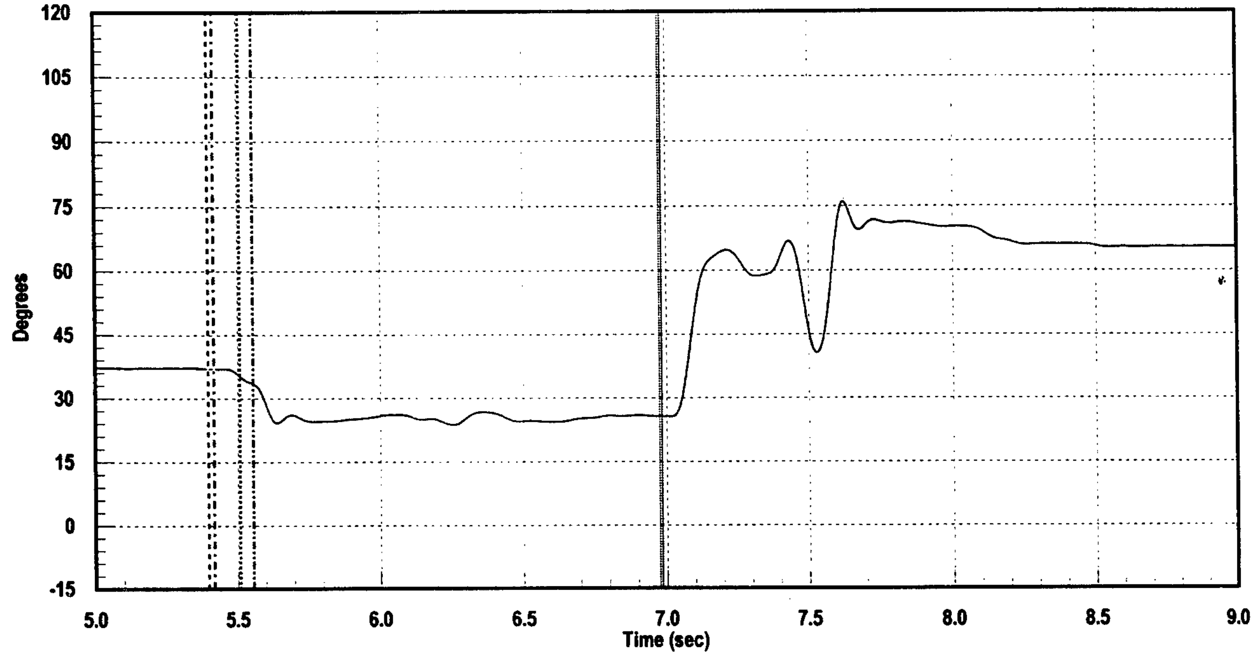
Right Shoulder Flexion/Extension



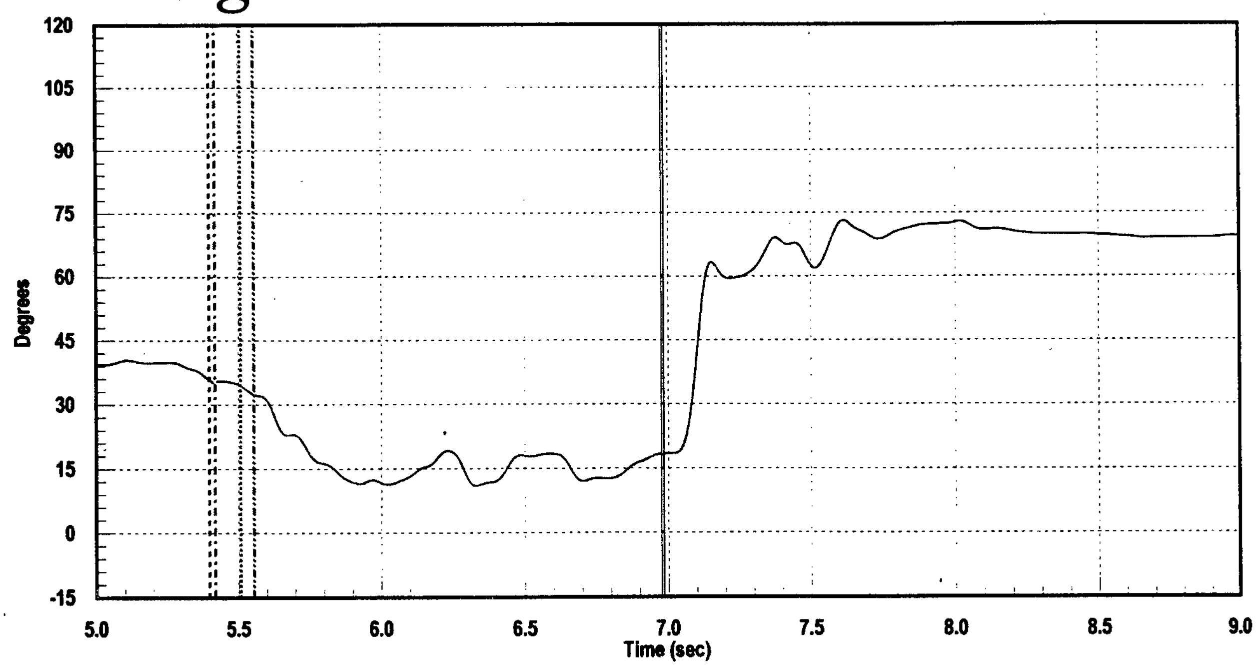
A-22

SL1295, 694 KEAS

Left Shoulder Medial/Lateral



Right Shoulder Medial/Lateral



A-23

Appendix H

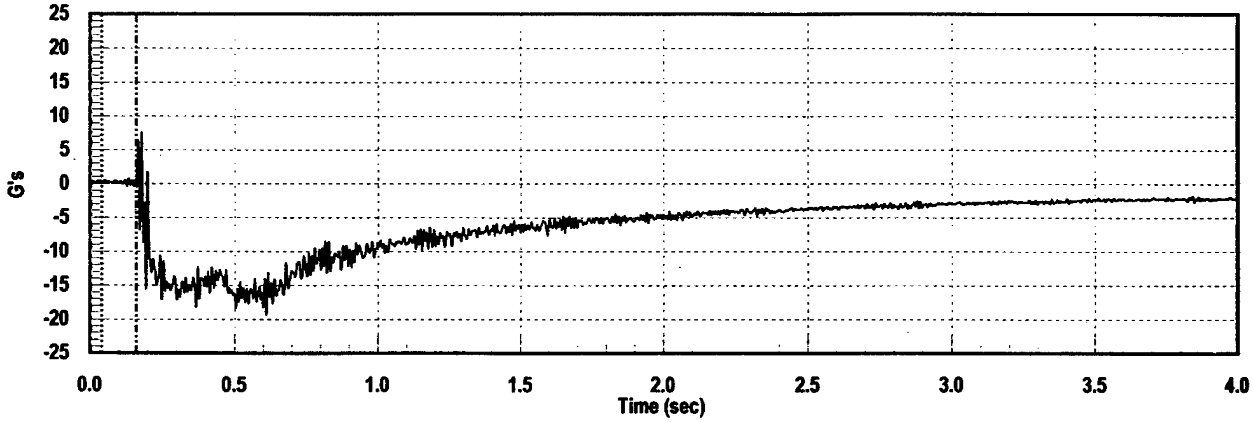
MiG-25 Processed Data

FL110005SK, 550 KEAS, 17,000 Ft
Processed Data

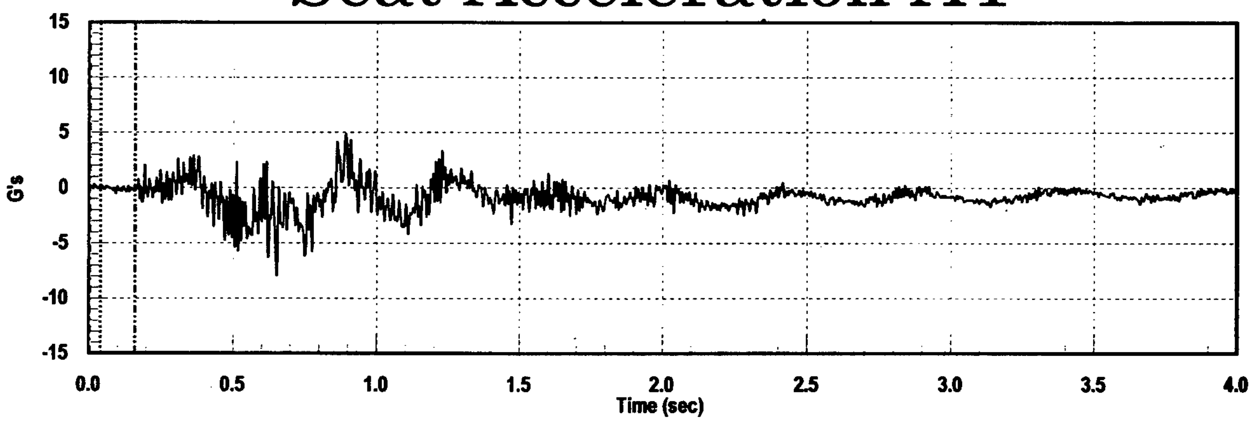
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL110005SK, 550 KEAS, 17,000 Ft

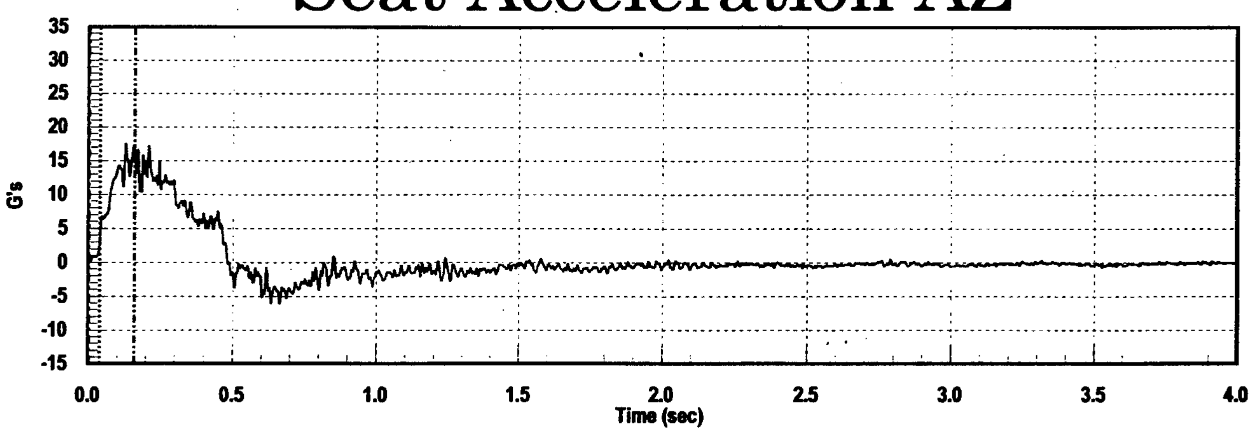
Seat Acceleration AX



Seat Acceleration AY



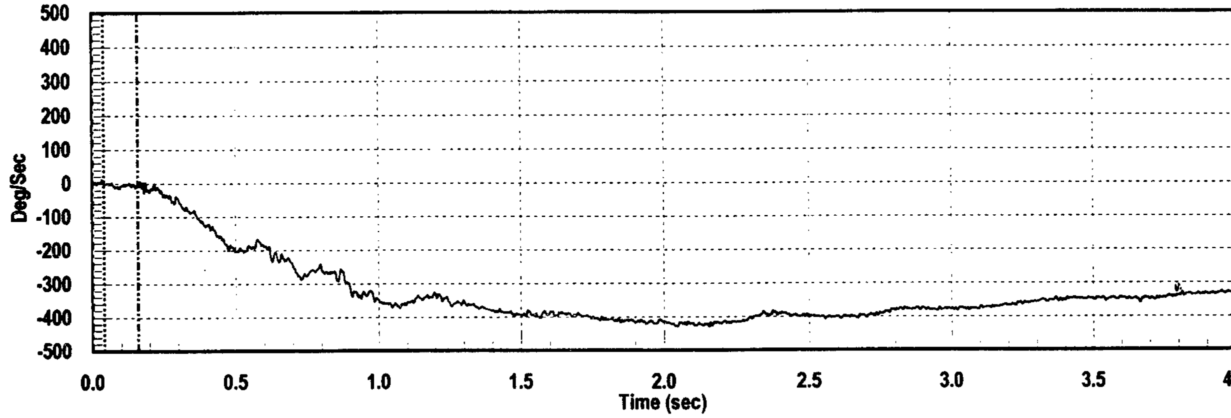
Seat Acceleration AZ



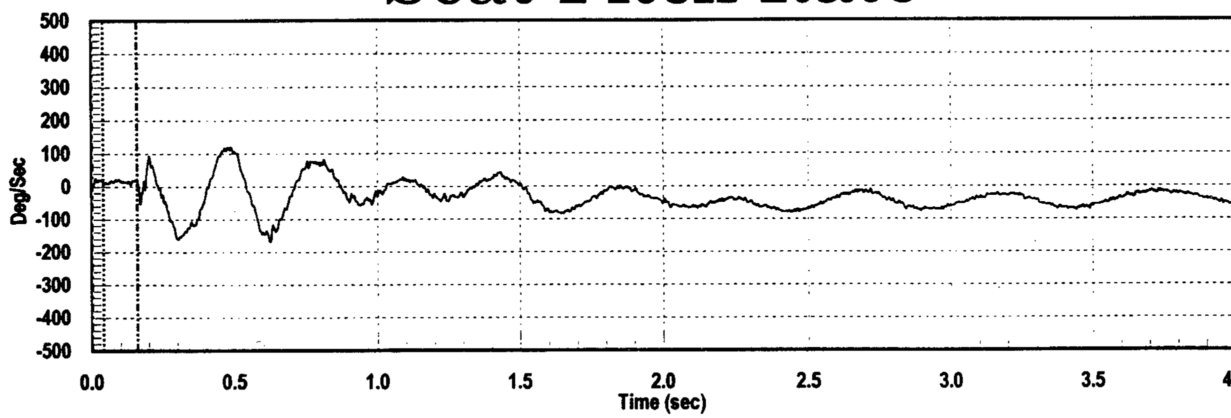
A-1

FL110005SK, 550 KEAS, 17,000 Ft

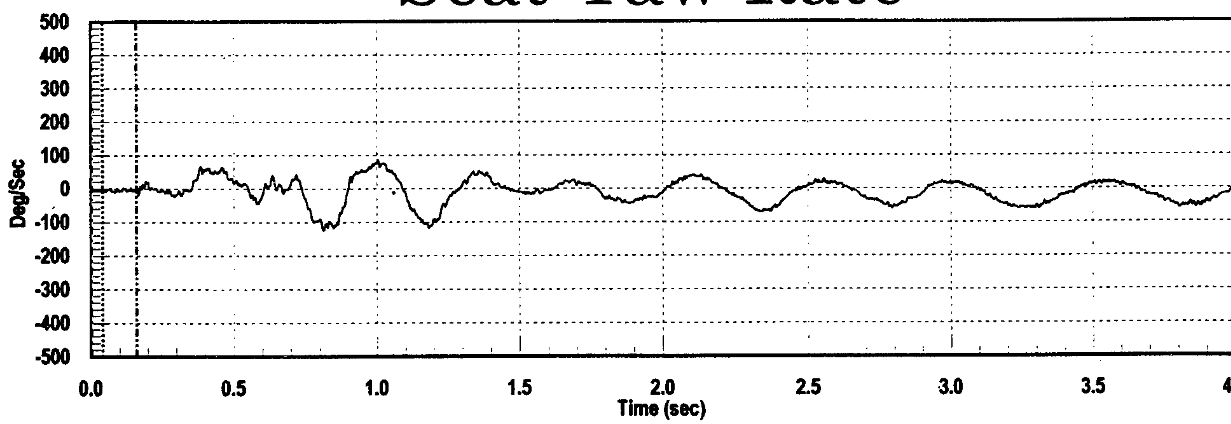
Seat Roll Rate



Seat Pitch Rate



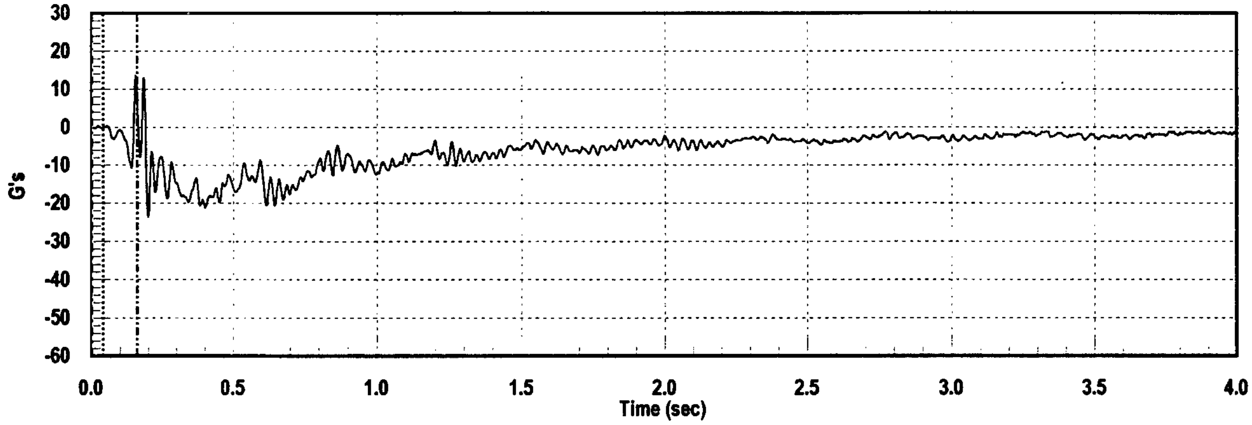
Seat Yaw Rate



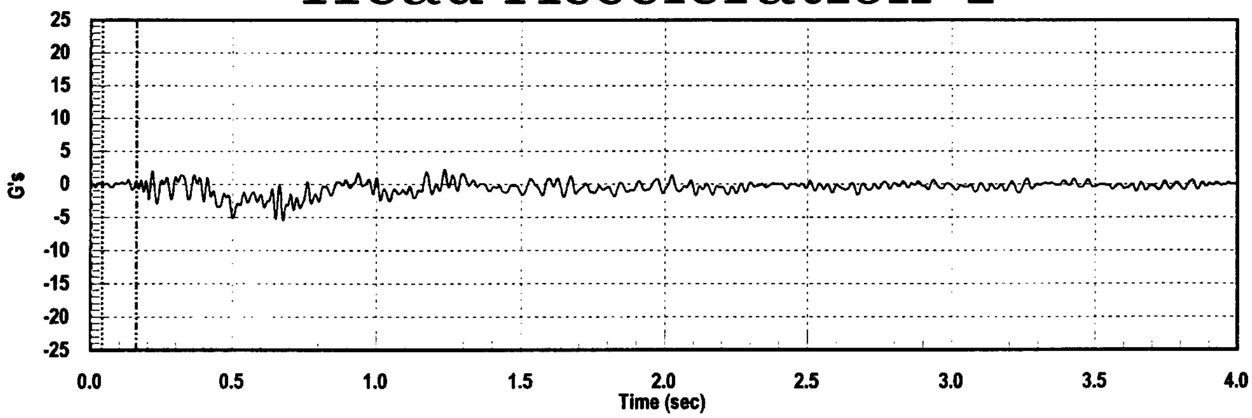
A-5

FL110005SK, 550 KEAS, 17,000 Ft

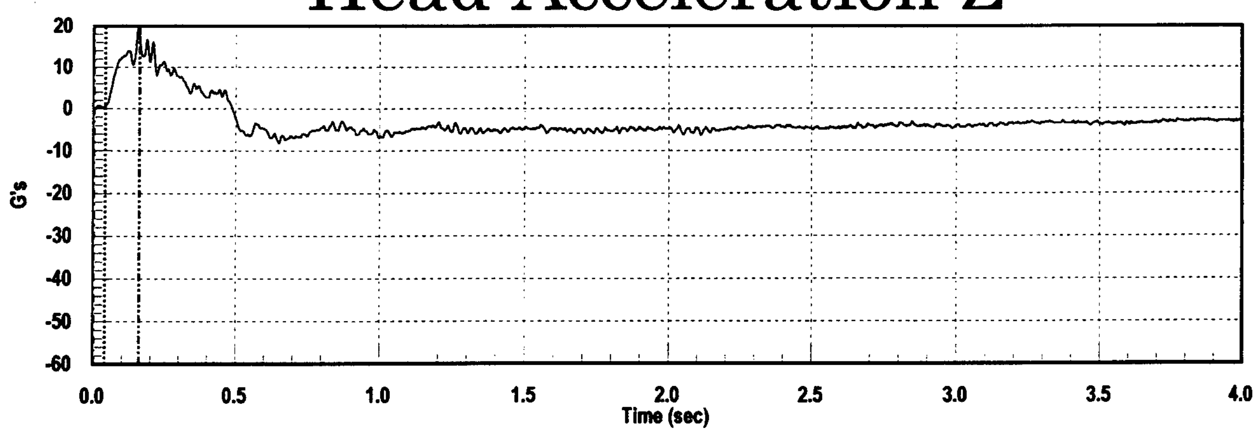
Head Acceleration X



Head Acceleration Y



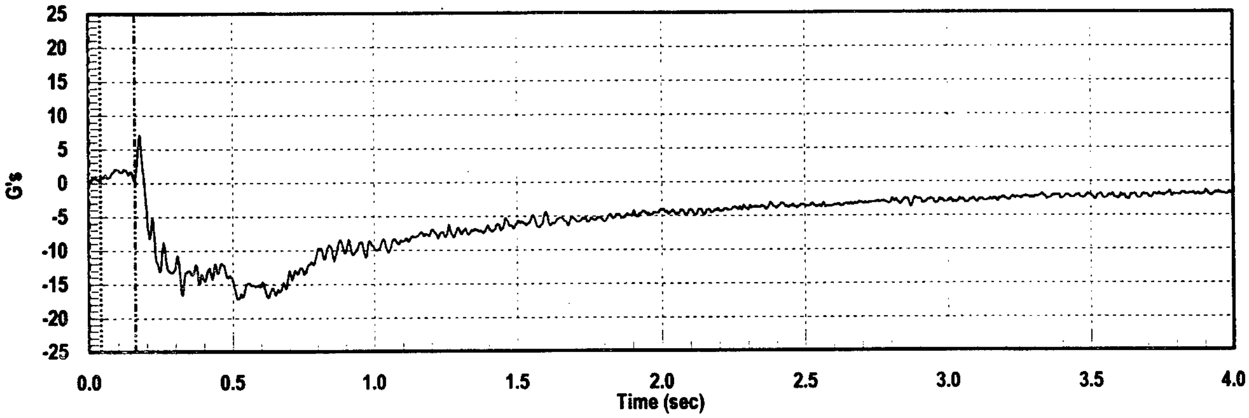
Head Acceleration Z



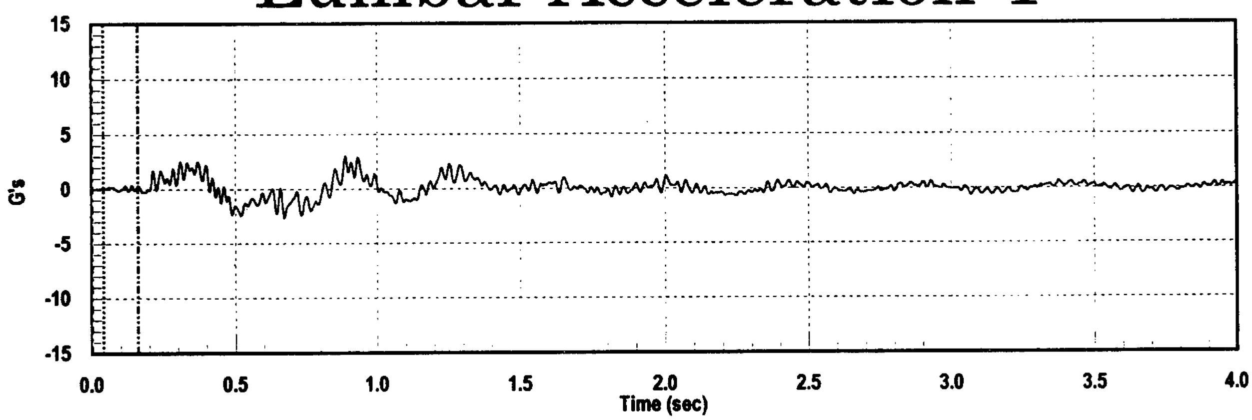
A-6

FL110005SK, 550 KEAS, 17,000 Ft

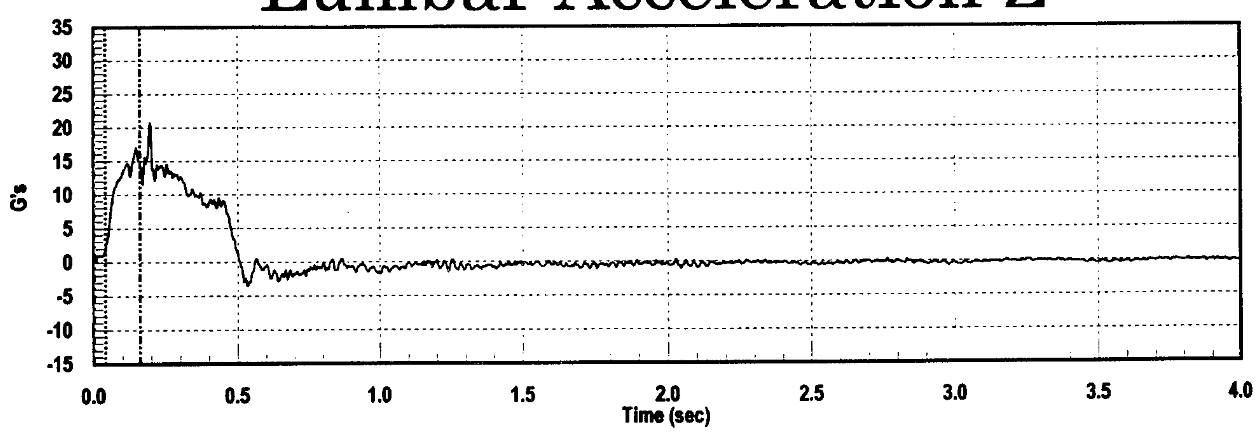
Lumbar Acceleration X



Lumbar Acceleration Y



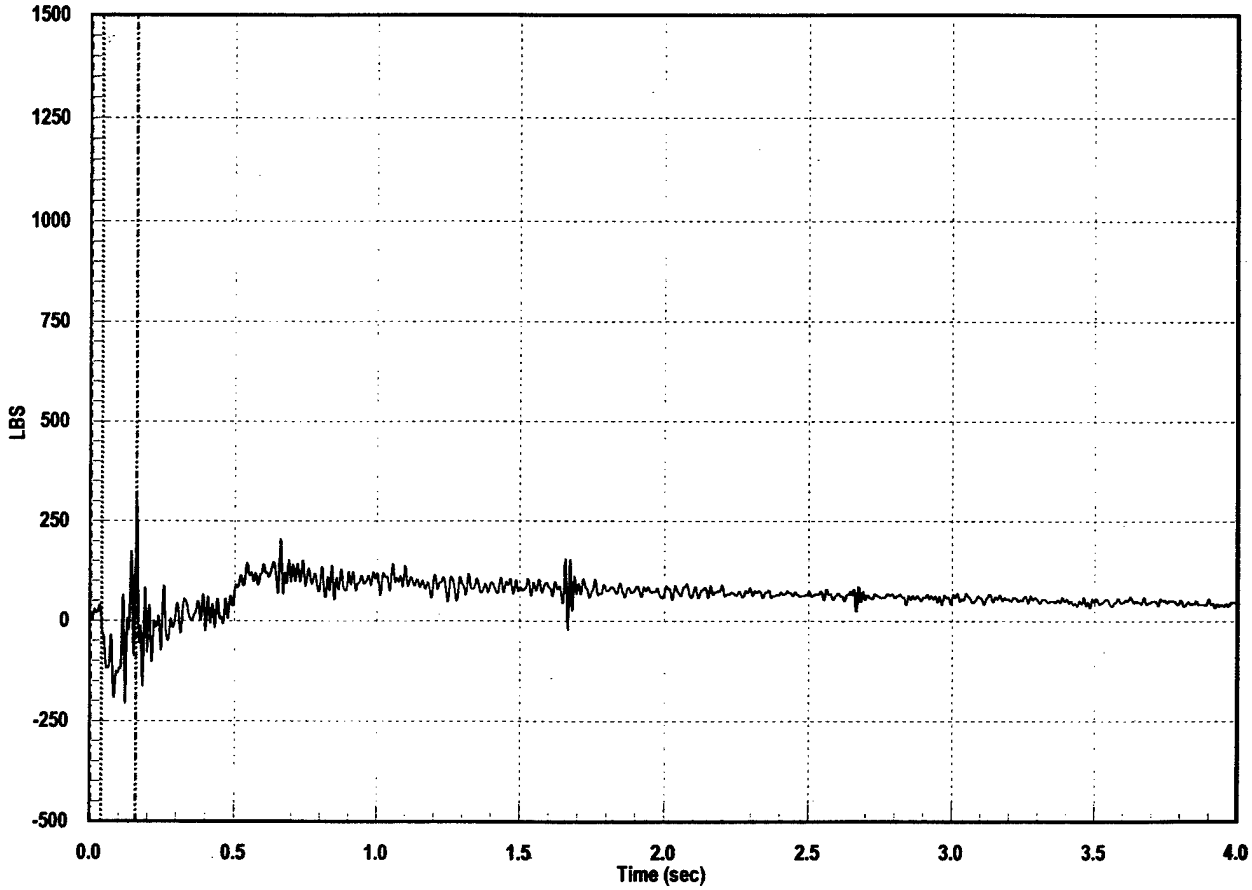
Lumbar Acceleration Z



A-8

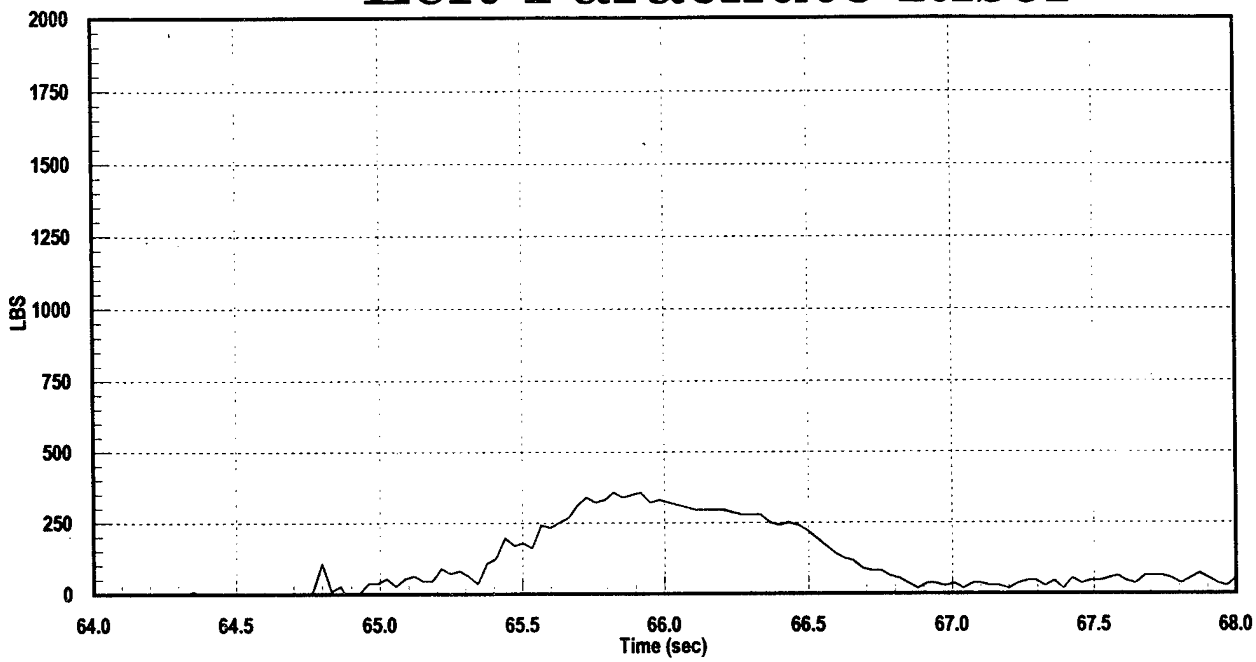
FL110005SK, 550 KEAS, 17,000 Ft

Head/Neck Force Z

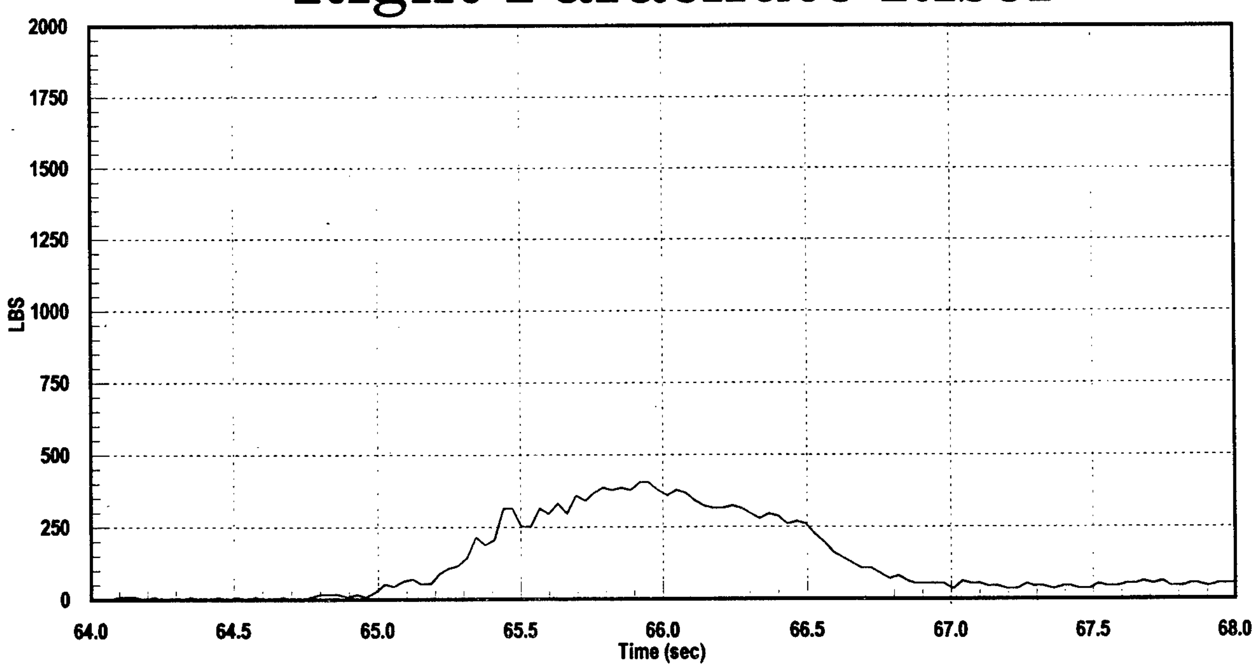


FL110005SK, 550 KEAS, 17,000 Ft

Left Parachute Riser



Right Parachute Riser



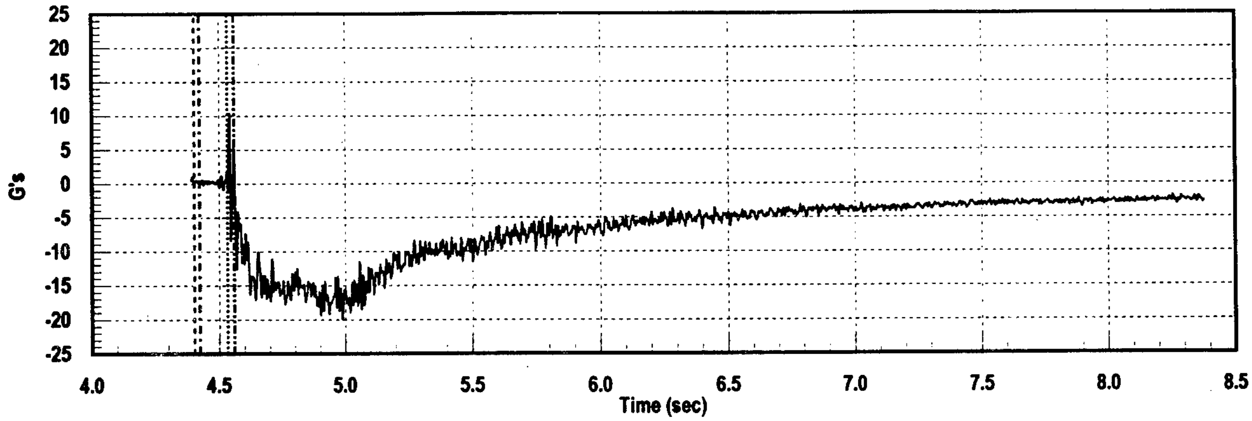
A-17

FL110005, 545 KEAS, 19,000 Ft
Processed Data

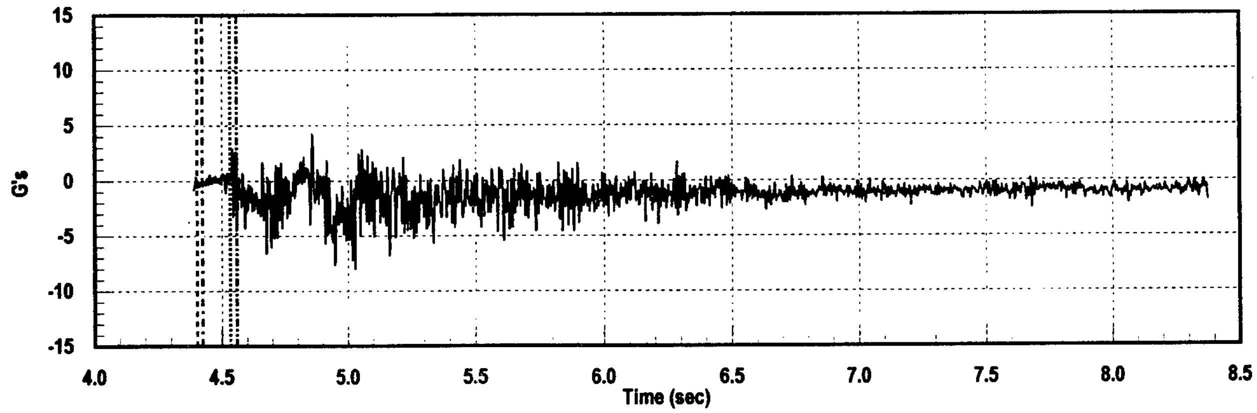
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL110005, 545 KEAS, 19,000 Ft

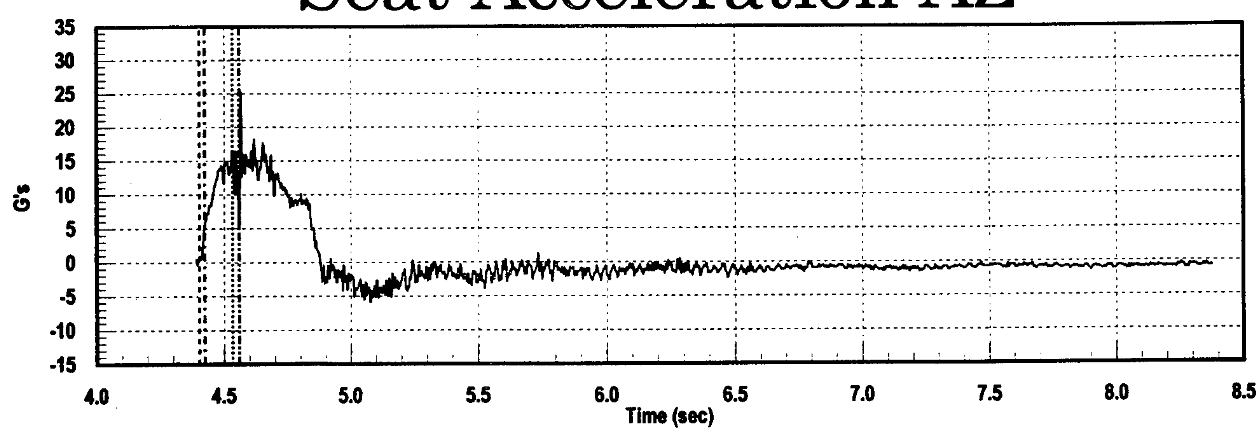
Seat Acceleration AX



Seat Acceleration AY



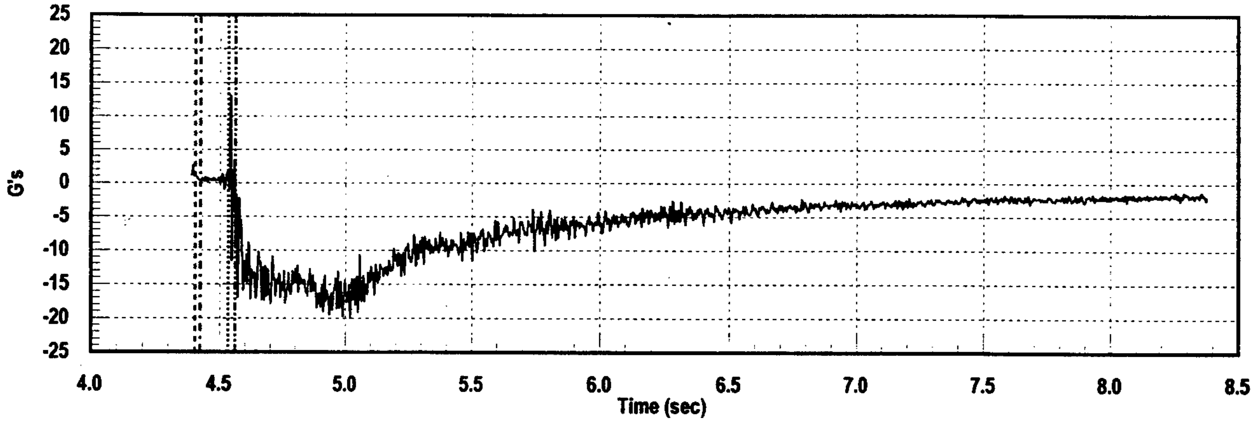
Seat Acceleration AZ



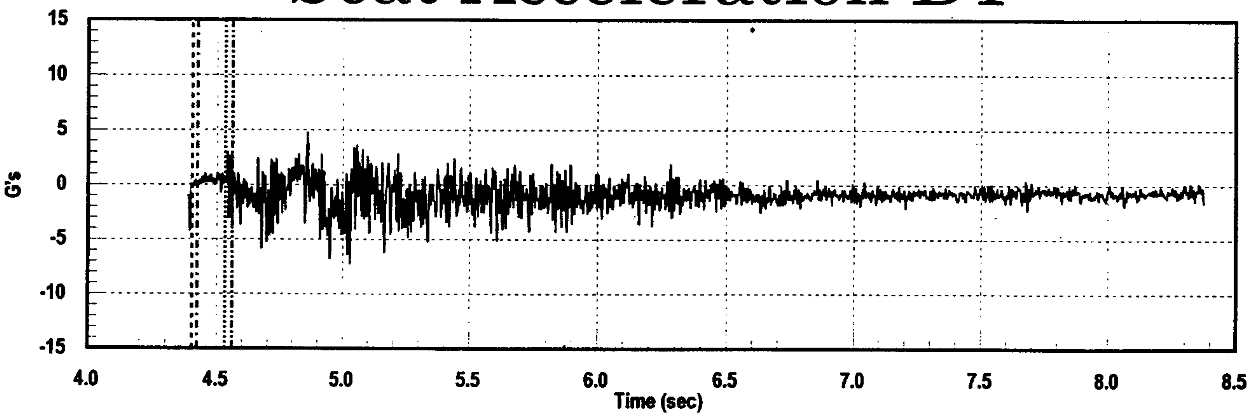
A-1

FL110005, 545 KEAS, 19,000 Ft

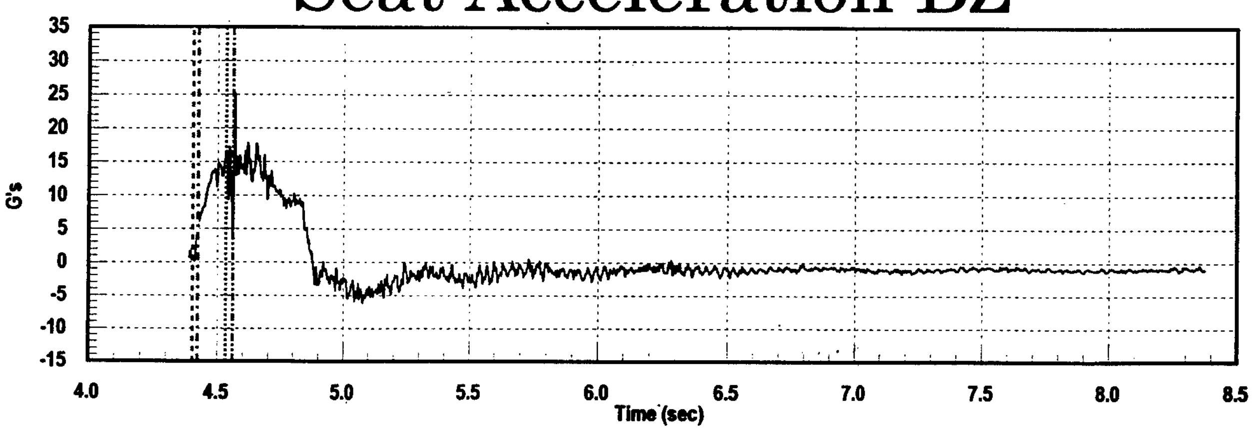
Seat Acceleration BX



Seat Acceleration BY



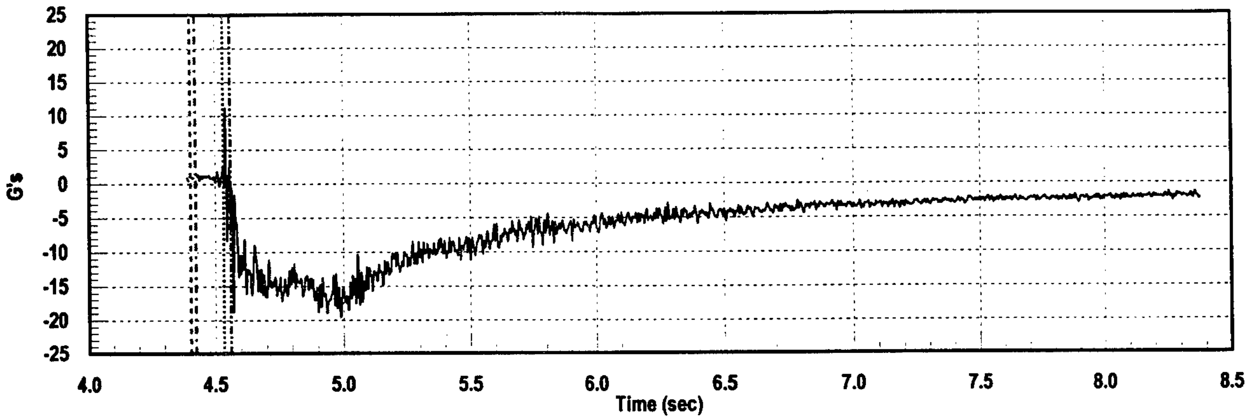
Seat Acceleration BZ



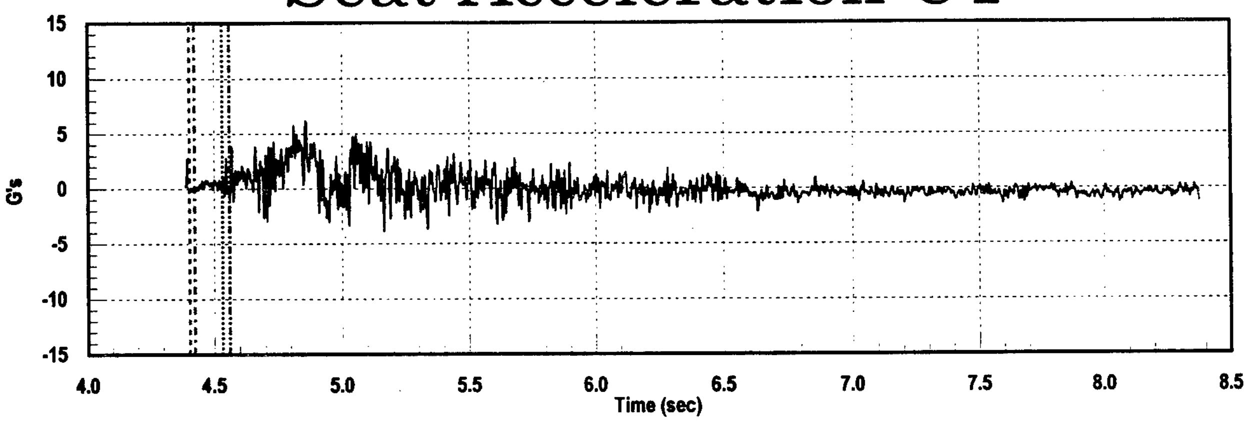
A-2

FL110005, 545 KEAS, 19,000 Ft

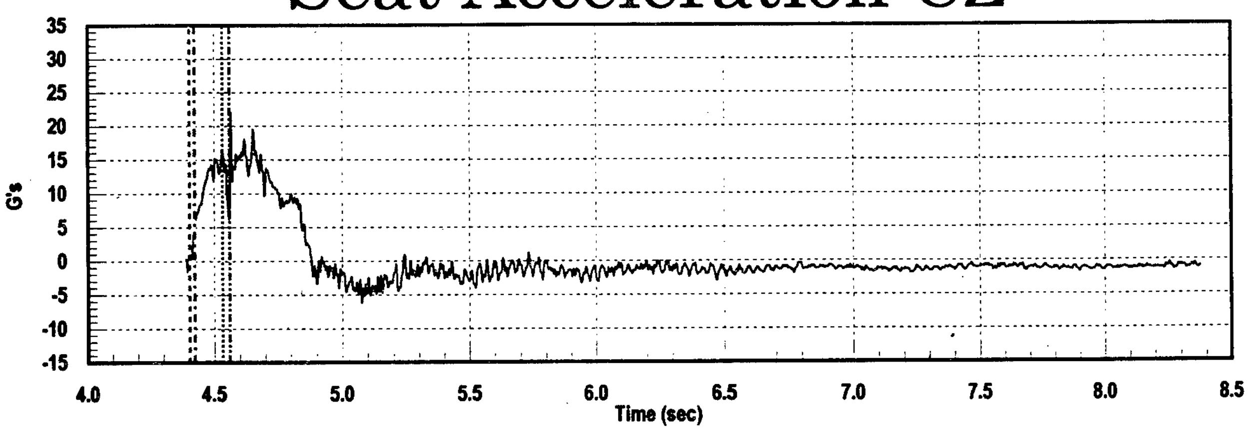
Seat Acceleration CX



Seat Acceleration CY



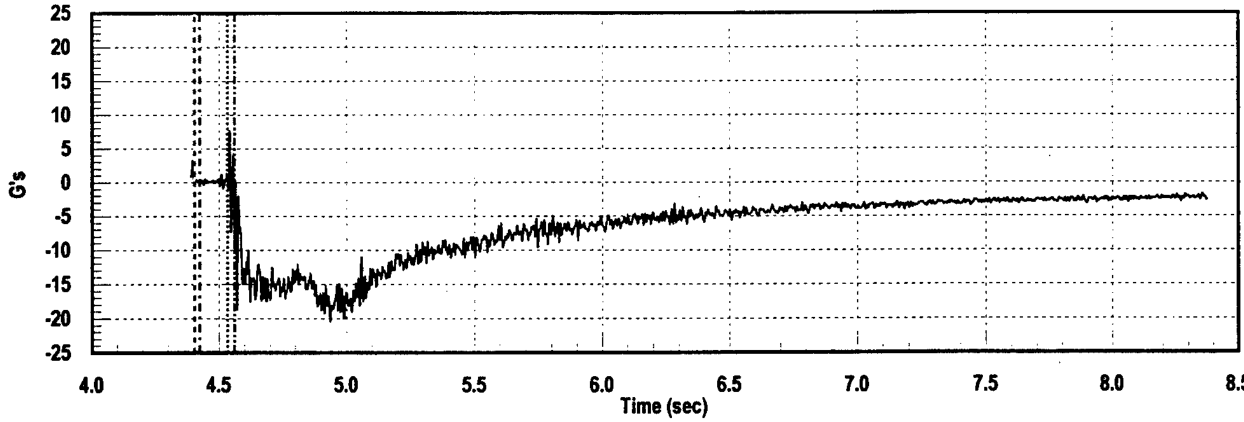
Seat Acceleration CZ



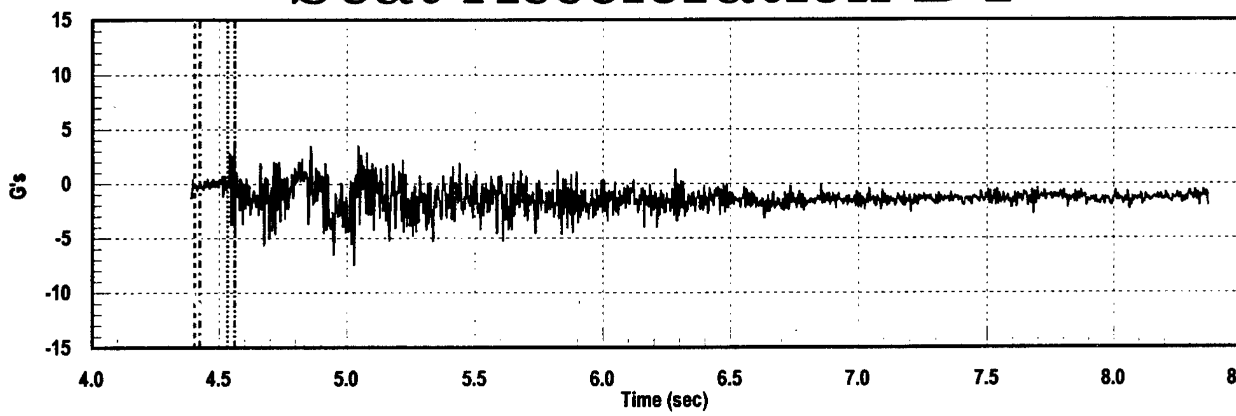
A-3

FL110005, 545 KEAS, 19,000 Ft

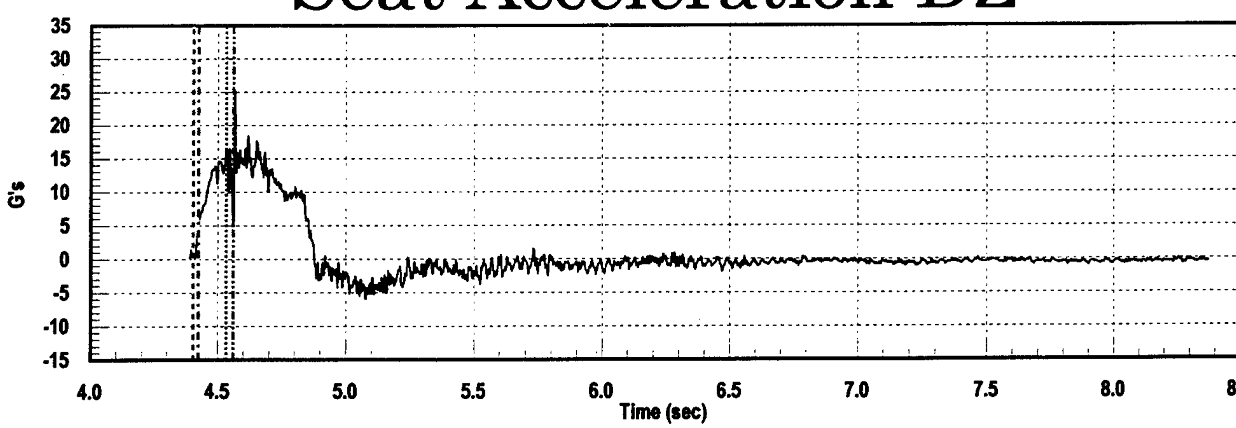
Seat Acceleration DX



Seat Acceleration DY



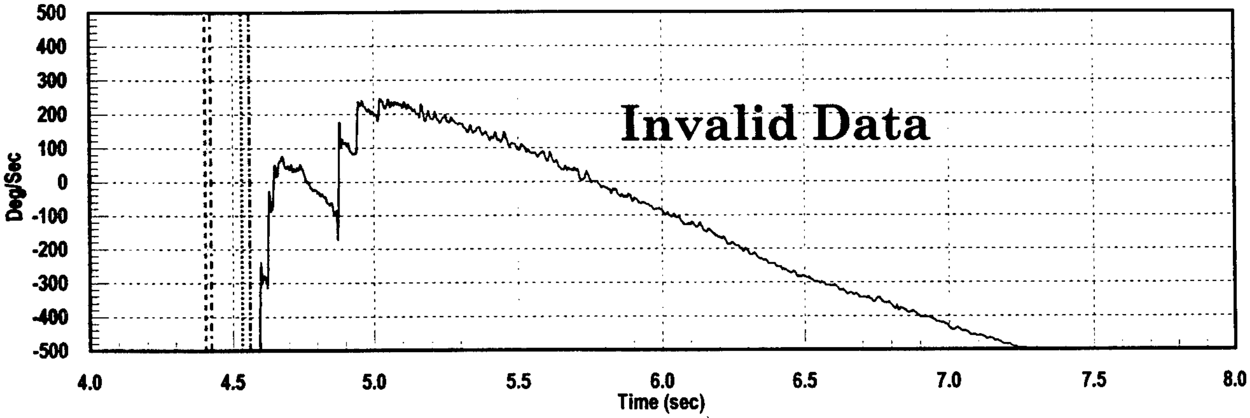
Seat Acceleration DZ



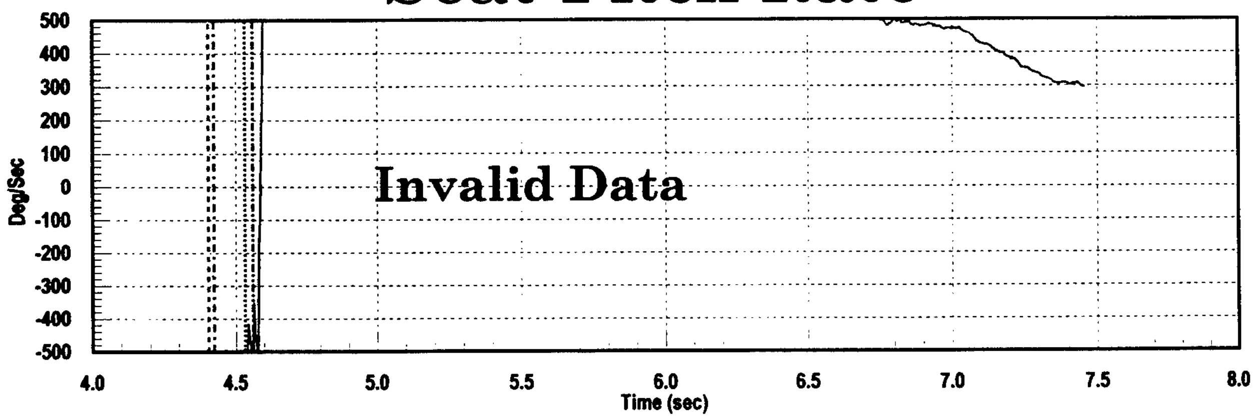
A-4

FL110005, 545 KEAS, 19,000 Ft

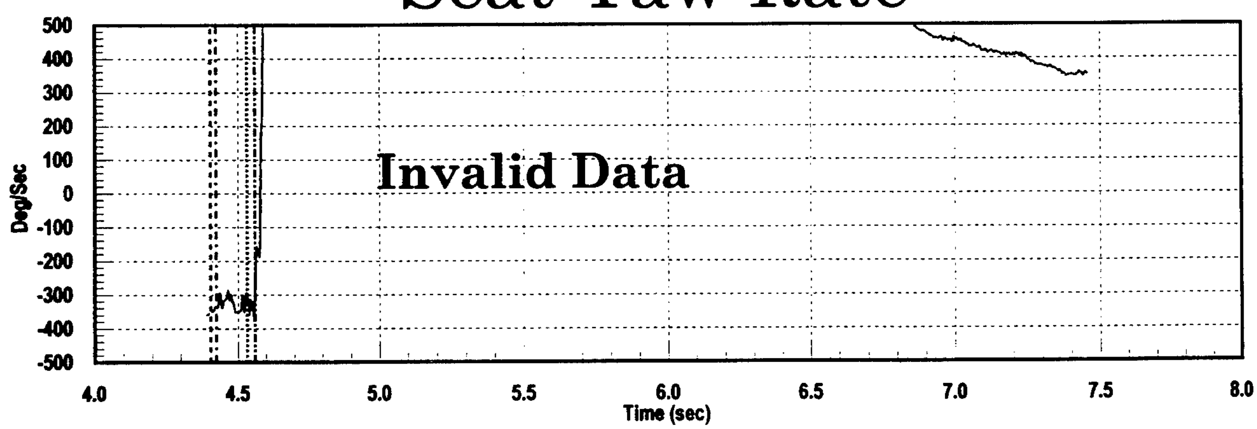
Seat Roll Rate



Seat Pitch Rate

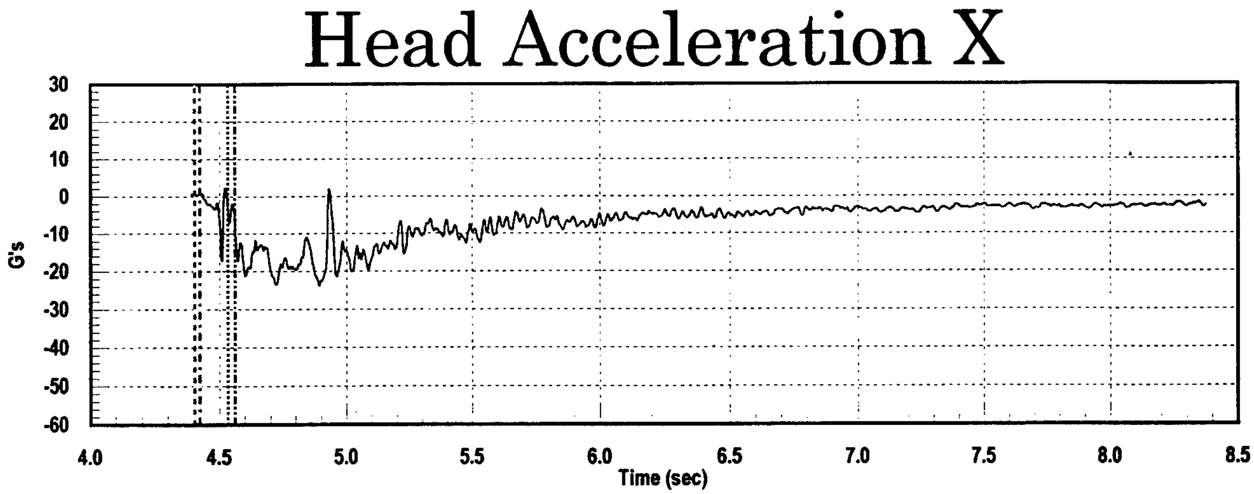


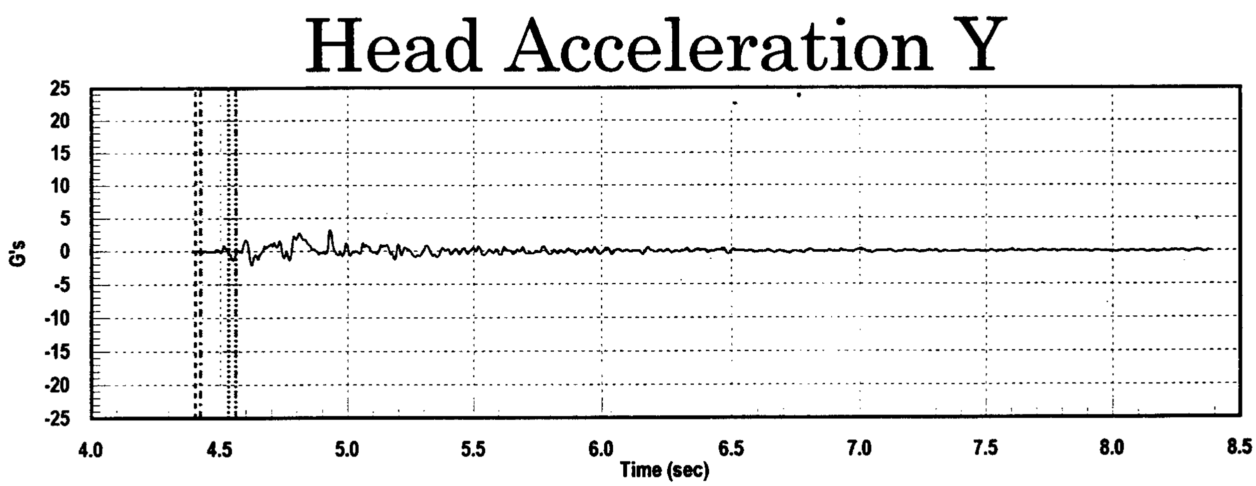
Seat Yaw Rate

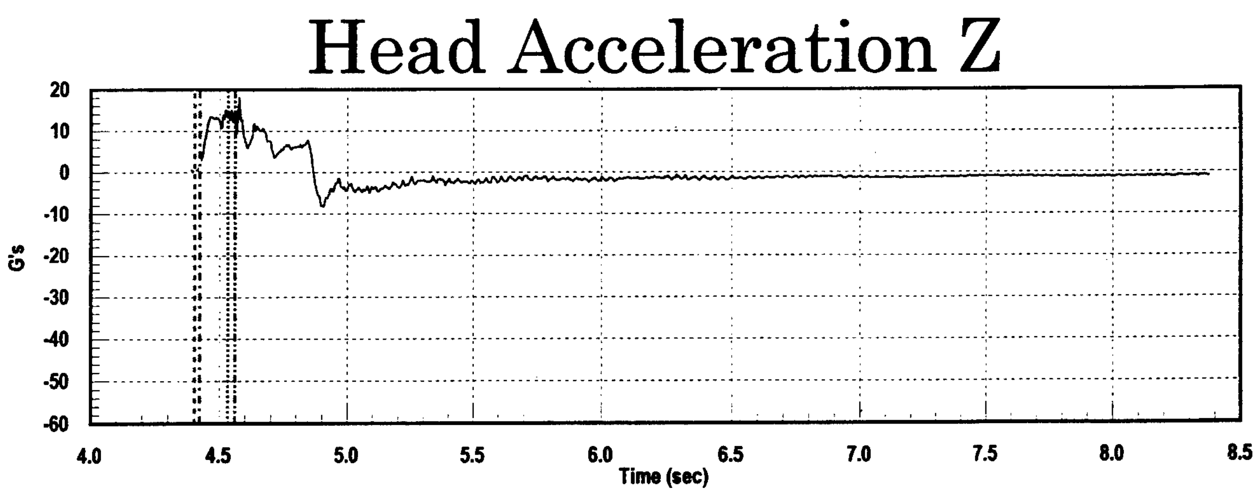


A-5

FL110005, 545 KEAS, 19,000 Ft



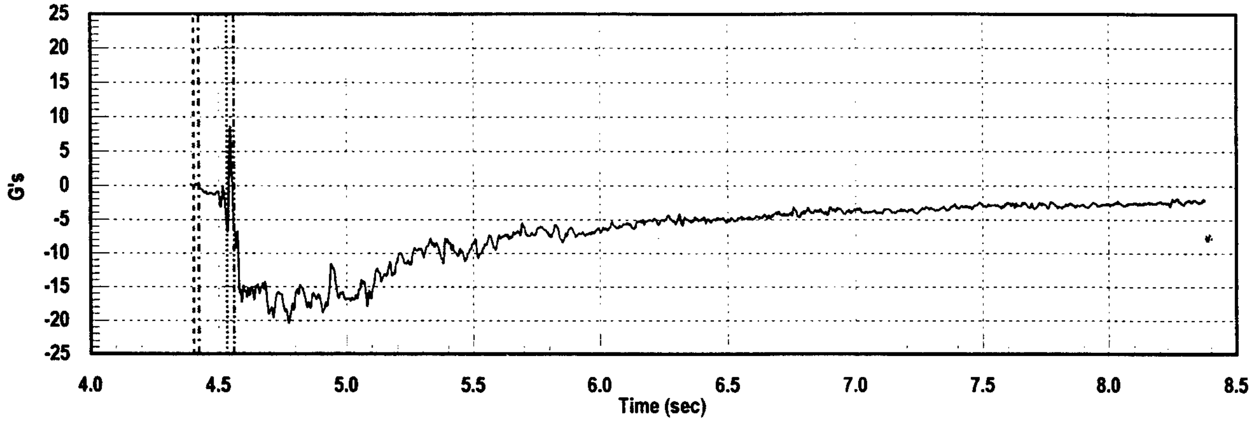




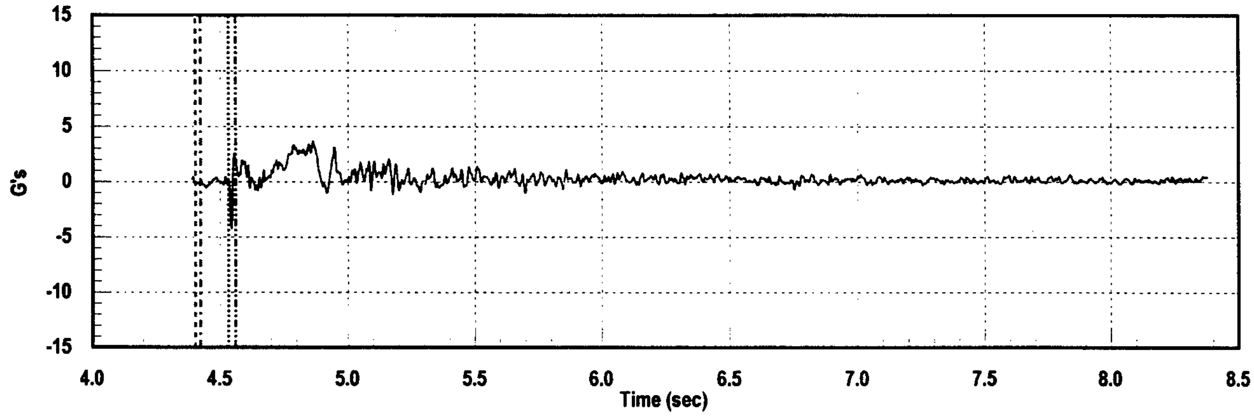
A-6

FL110005, 545 KEAS, 19,000 Ft

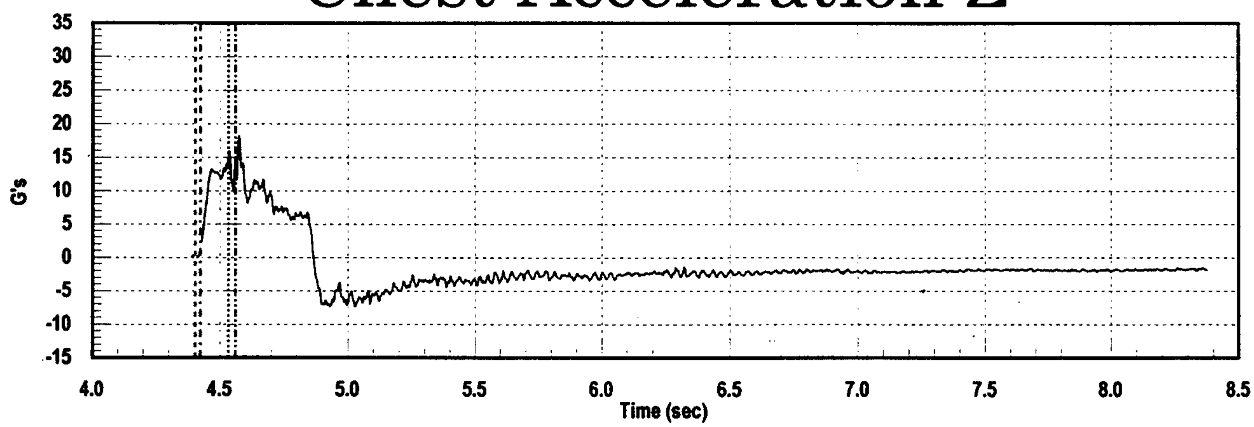
Chest Acceleration X



Chest Acceleration Y

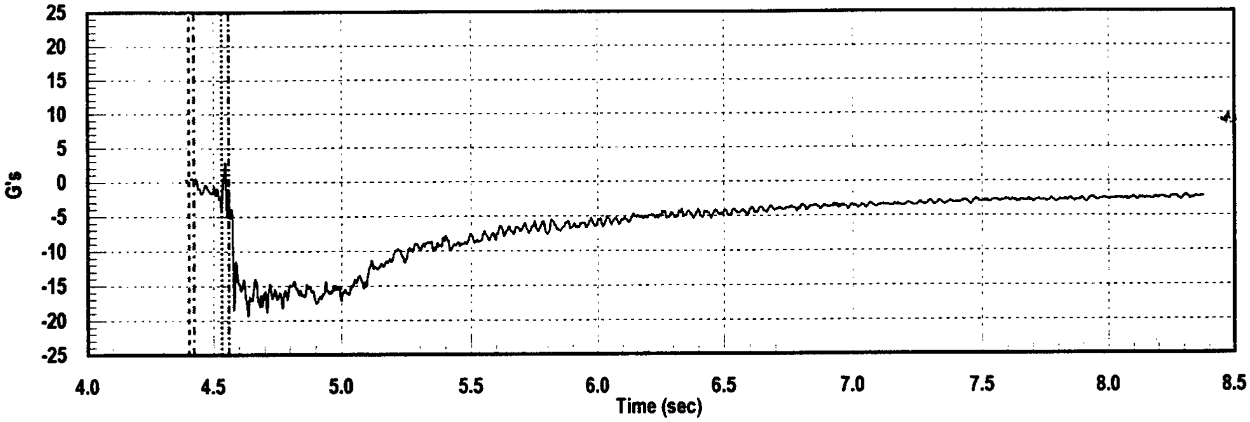


Chest Acceleration Z

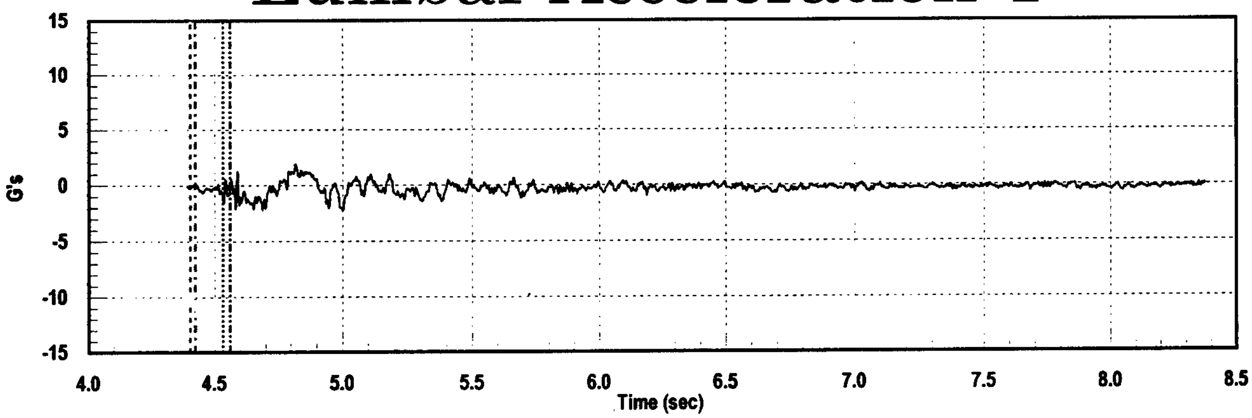


FL110005, 545 KEAS, 19,000 Ft

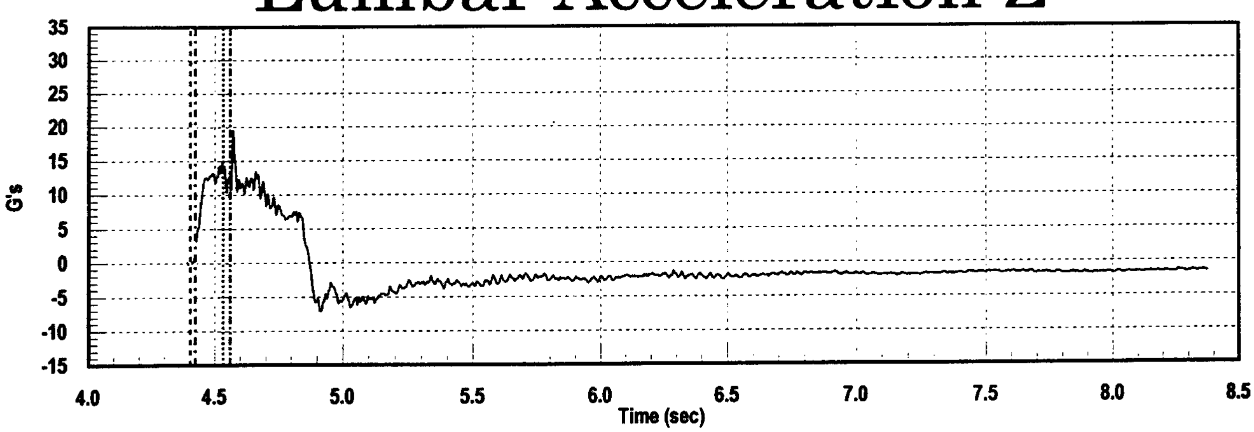
Lumbar Acceleration X



Lumbar Acceleration Y

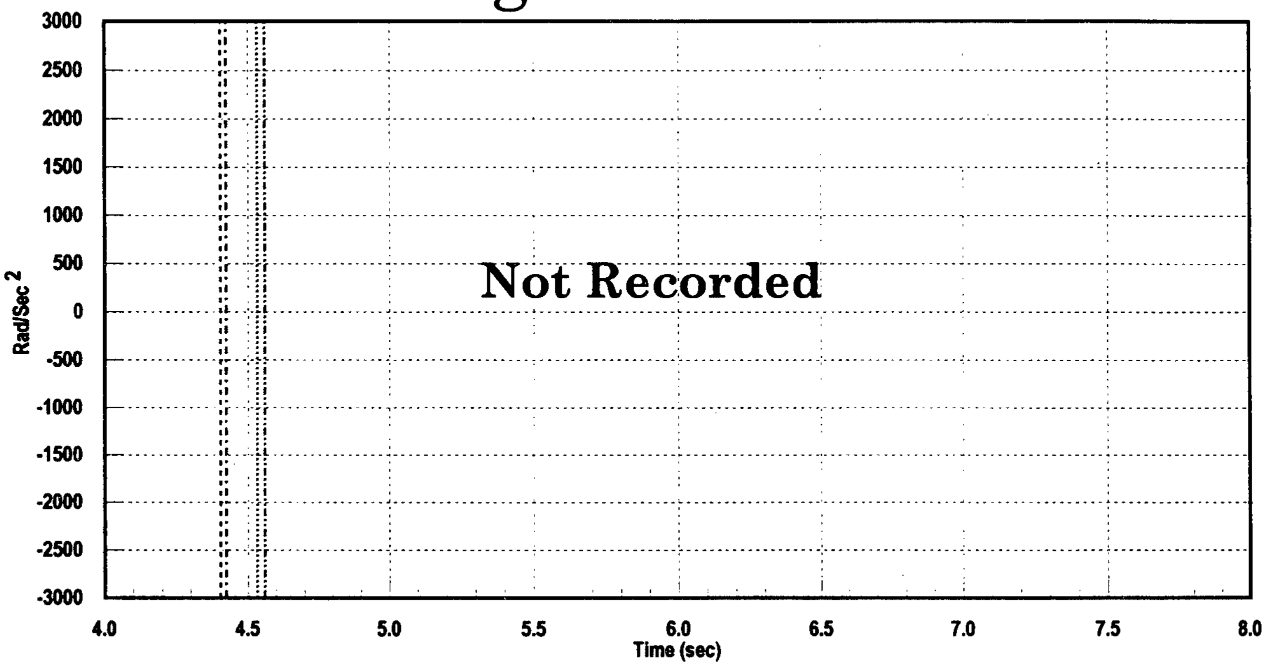


Lumbar Acceleration Z

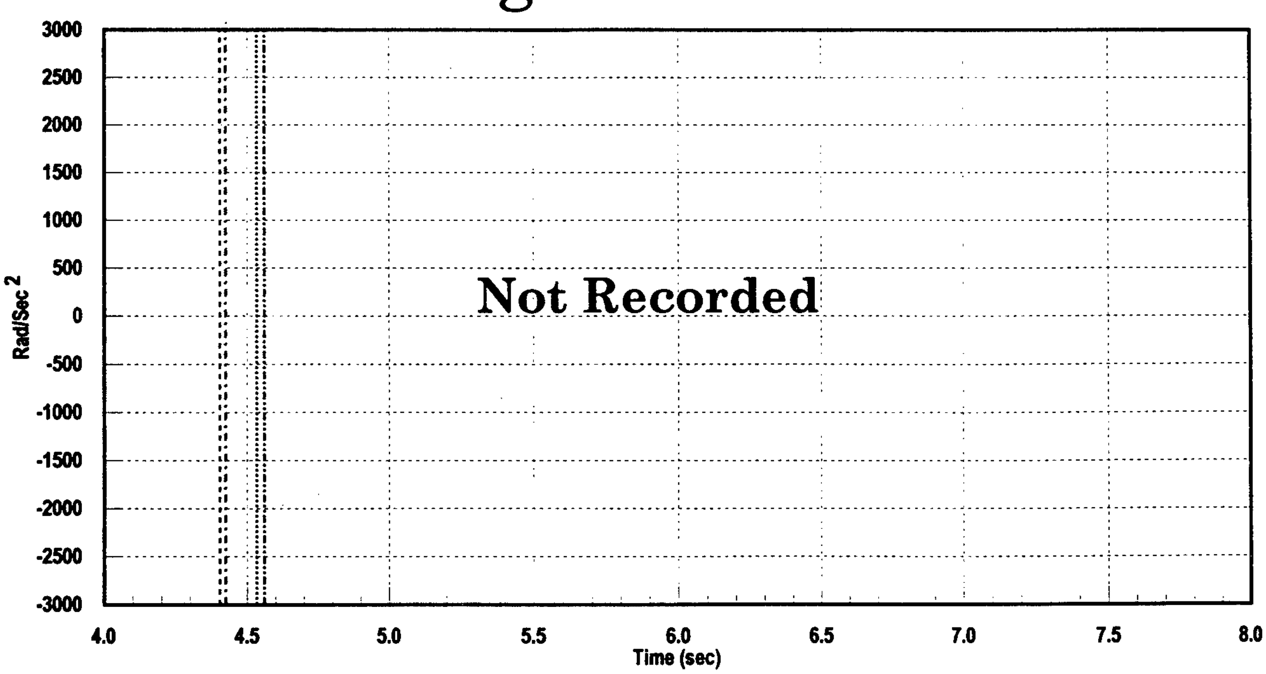


FL110005, 545 KEAS, 19,000 Ft

Head Angular Acceleration Y



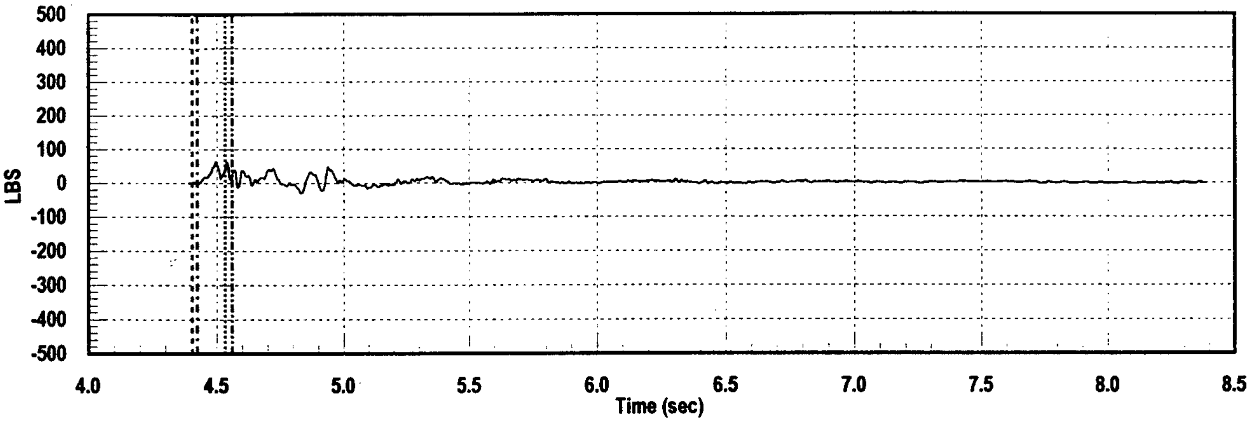
Chest Angular Acceleration Y



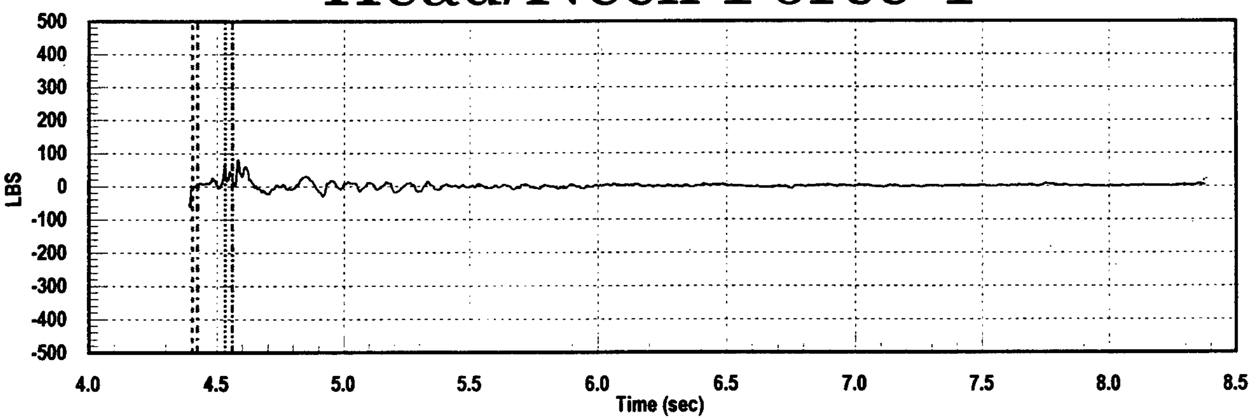
A-9

FL110005, 545 KEAS, 19,000 Ft

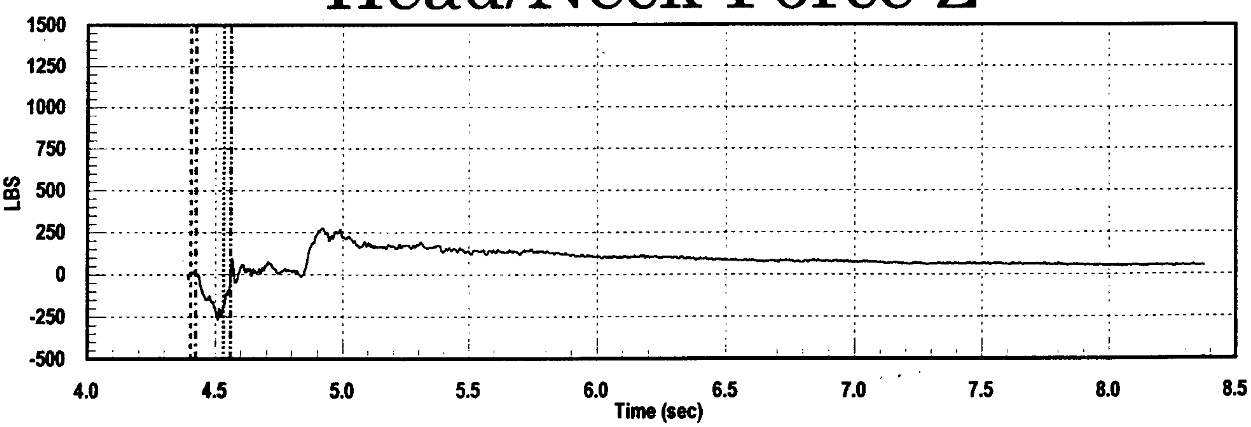
Head/Neck Force X



Head/Neck Force Y



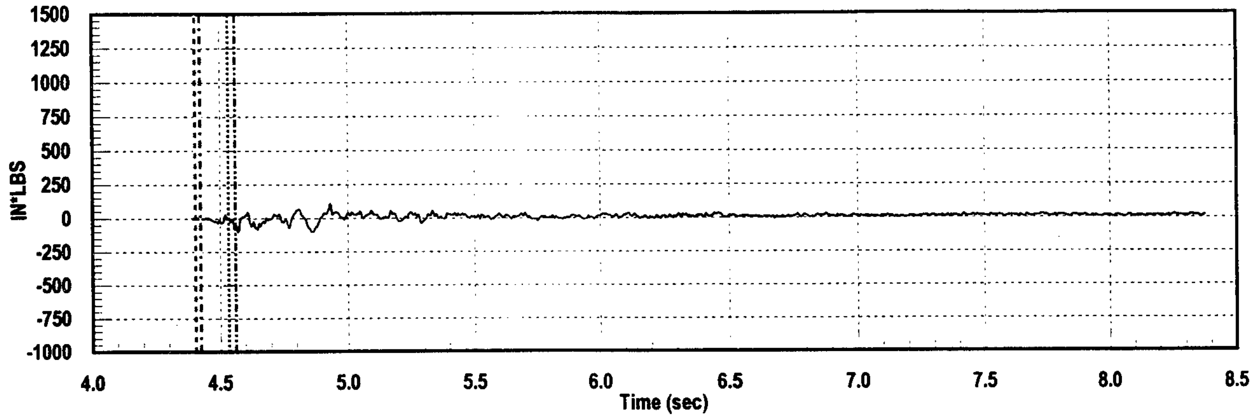
Head/Neck Force Z



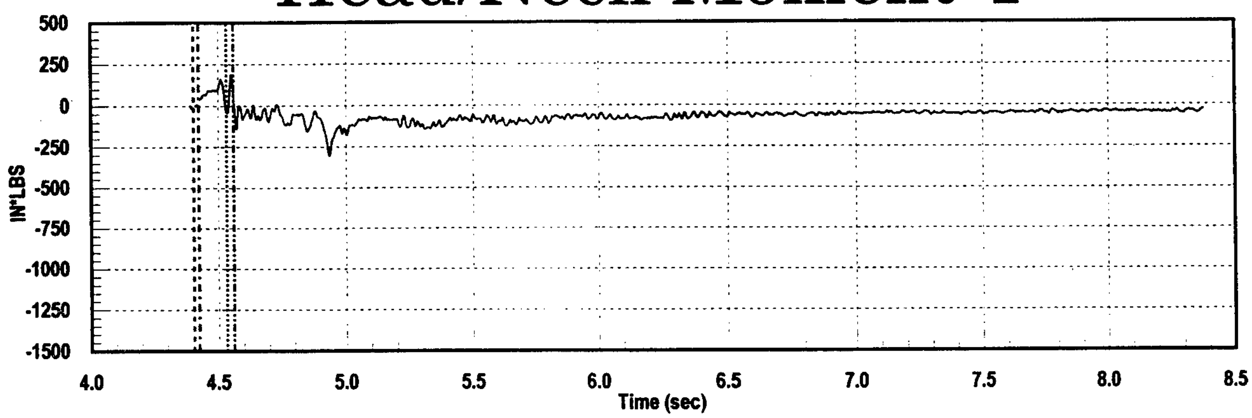
A-10

FL110005, 545 KEAS, 19,000 Ft

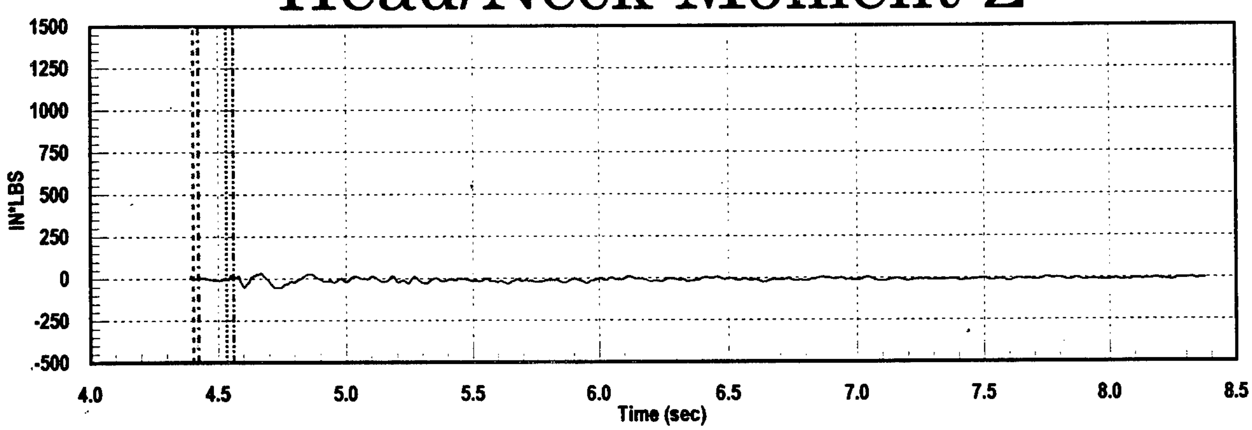
Head/Neck Moment X



Head/Neck Moment Y



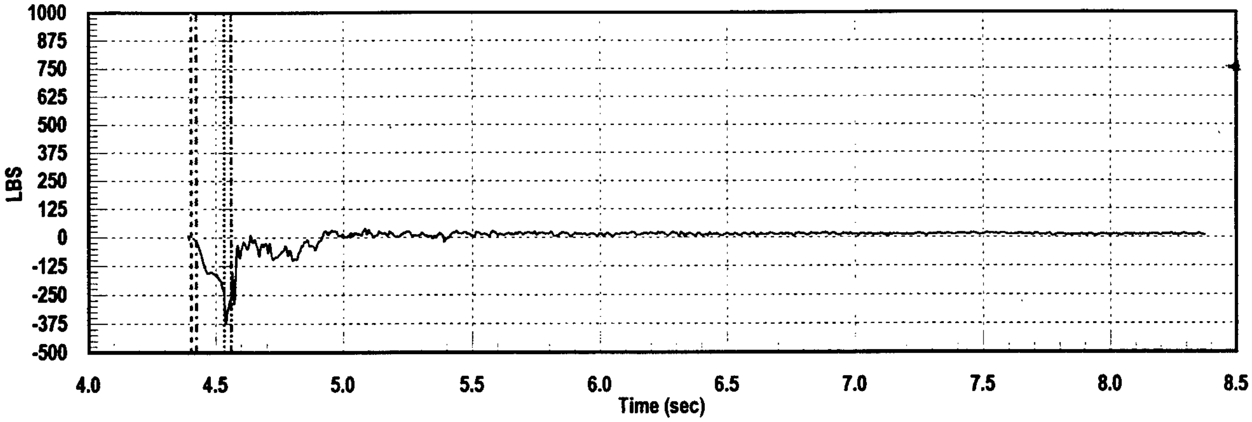
Head/Neck Moment Z



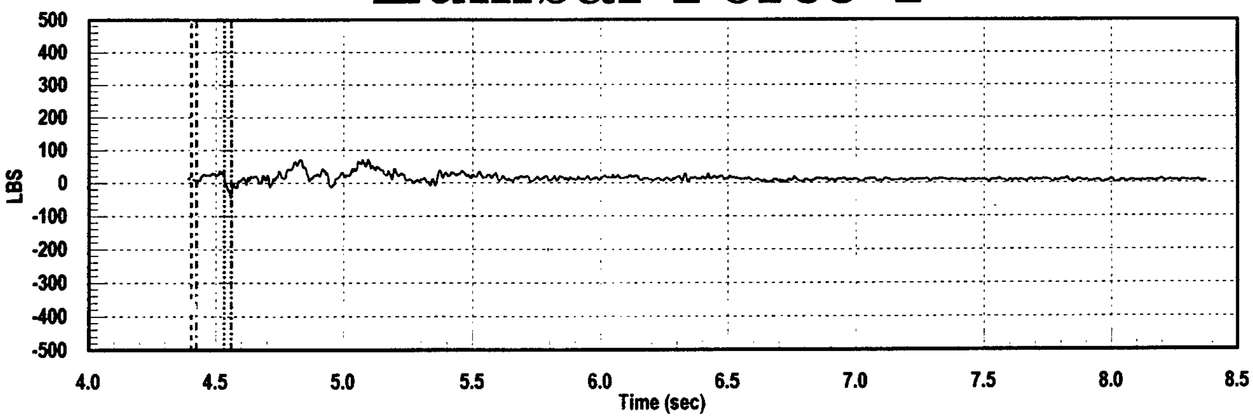
A-11

FL110005, 545 KEAS, 19,000 Ft

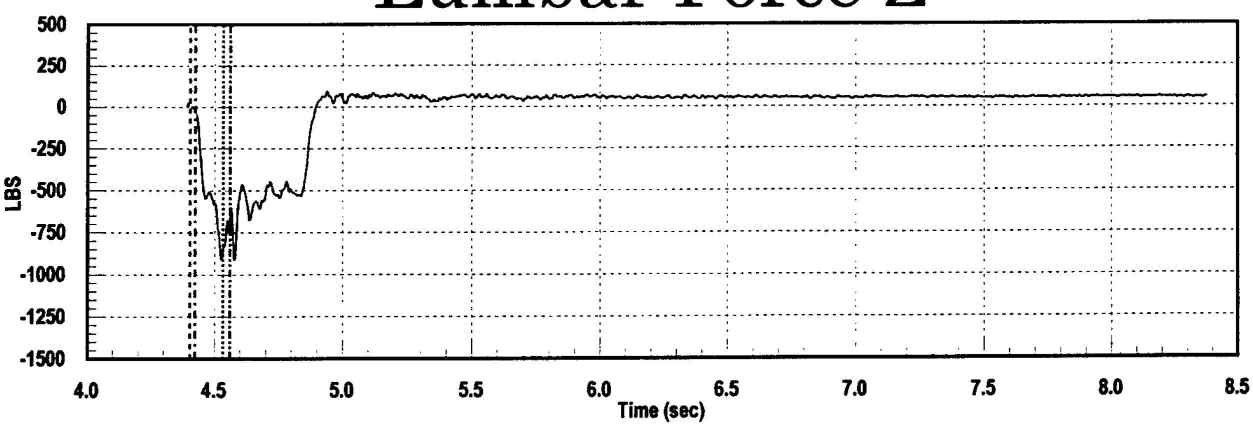
Lumbar Force X



Lumbar Force Y



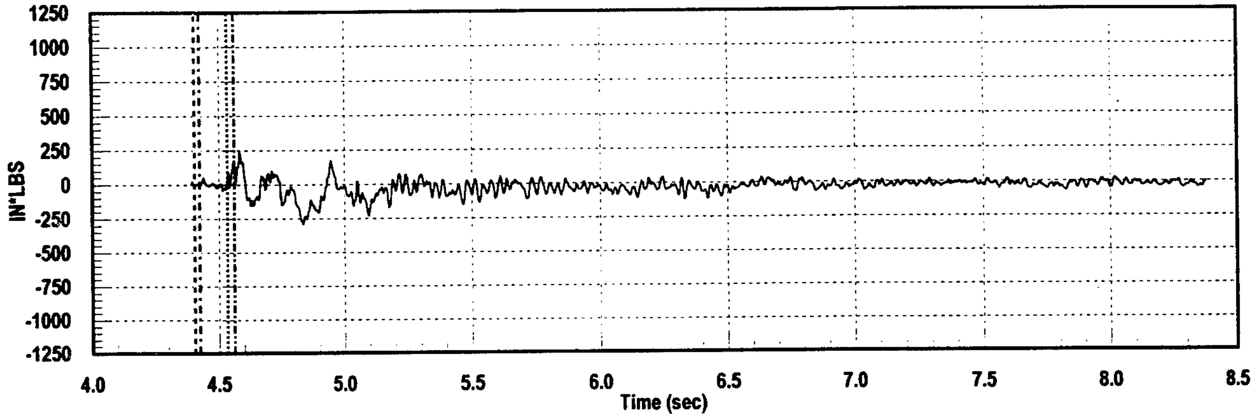
Lumbar Force Z



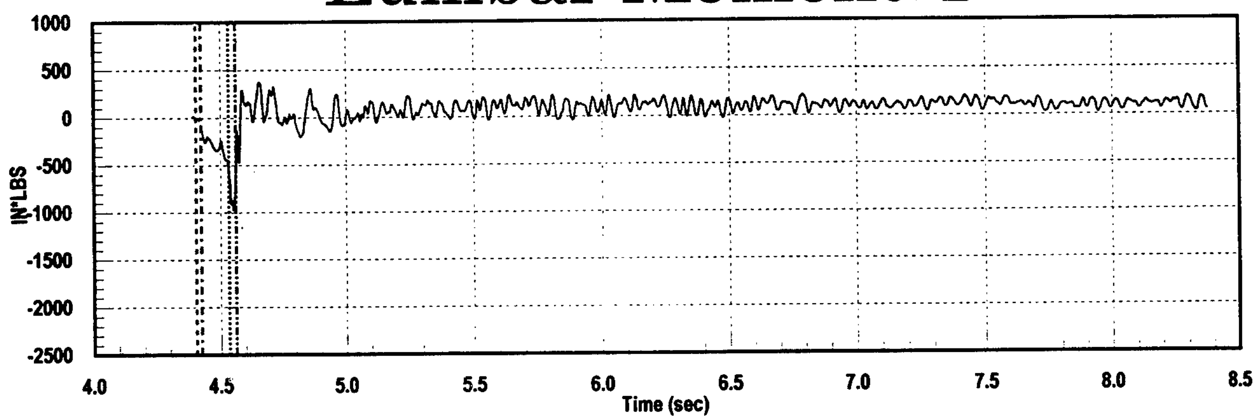
A-12

FL110005, 545 KEAS, 19,000 Ft

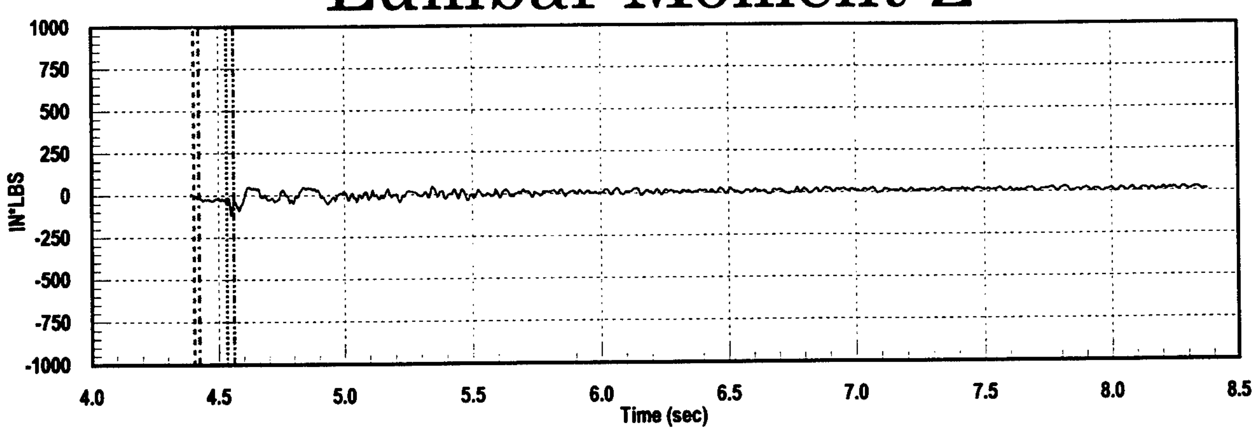
Lumbar Moment X



Lumbar Moment Y



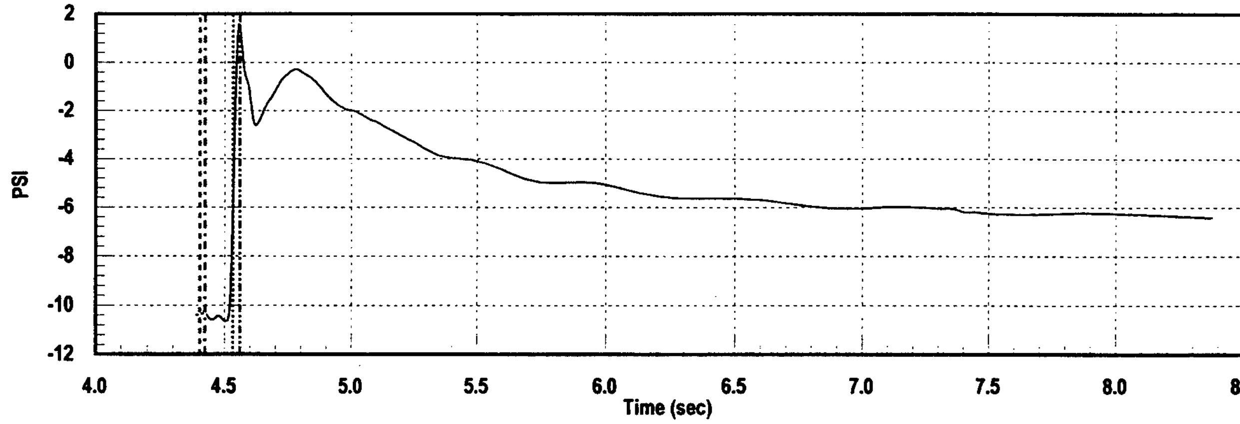
Lumbar Moment Z



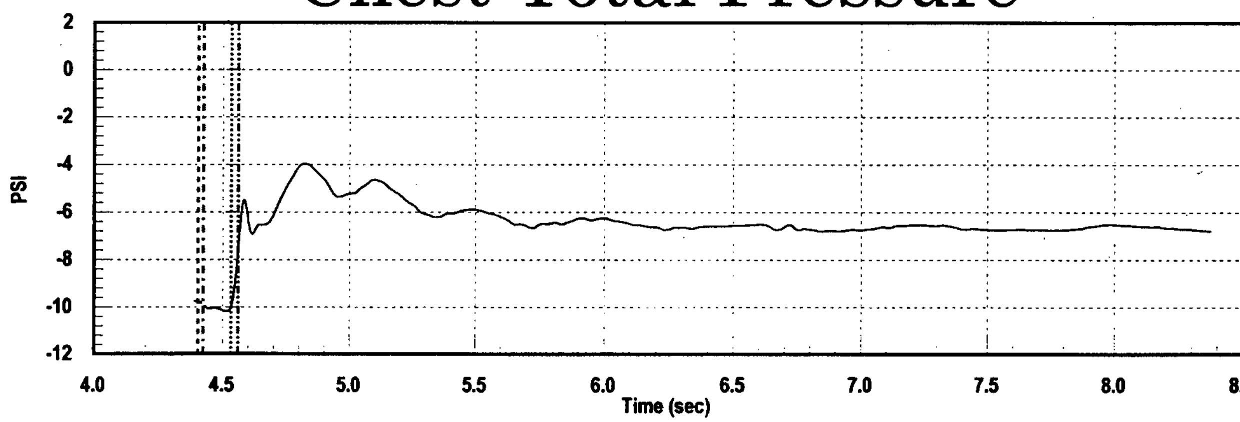
A-13

FL110005, 545 KEAS, 19,000 Ft

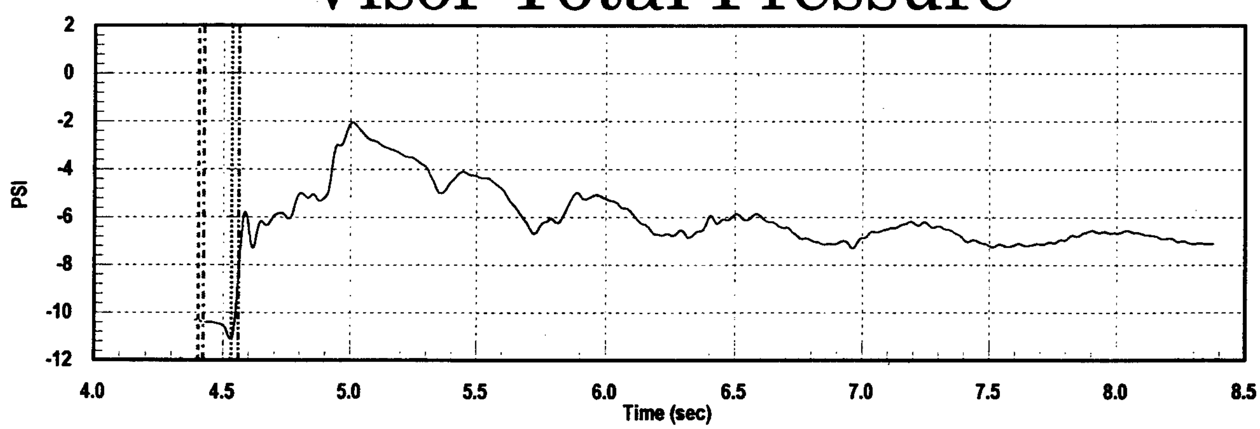
Windblast Deflector Total Pressure



Chest Total Pressure



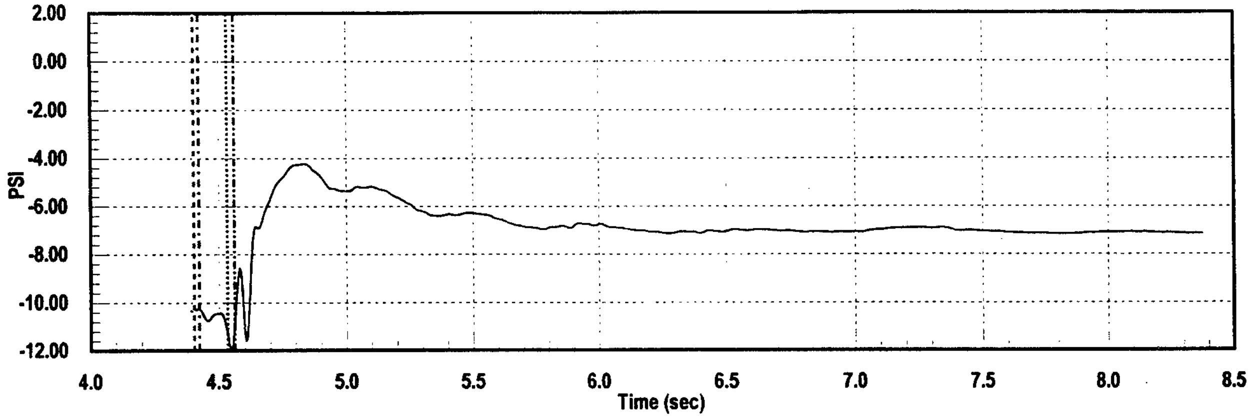
Visor Total Pressure



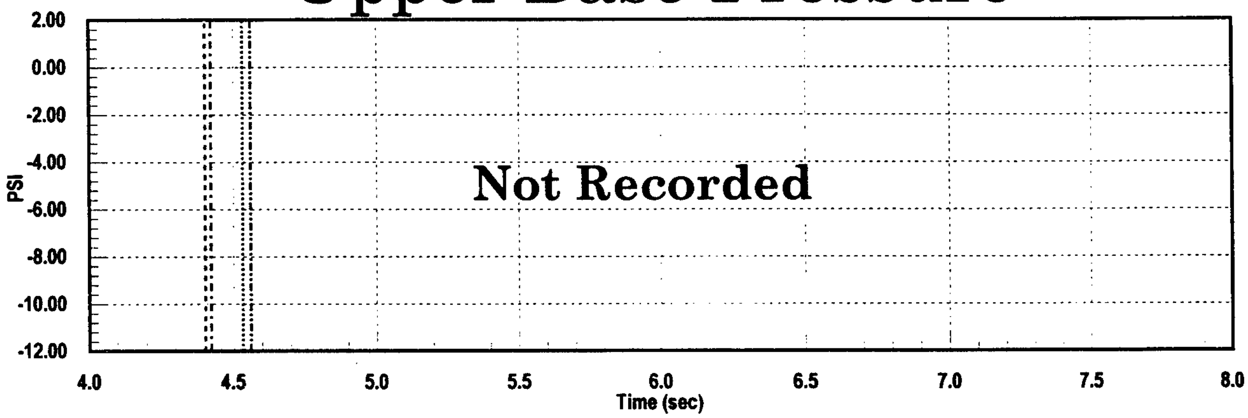
A-14

FL110005, 545 KEAS, 19,000 Ft

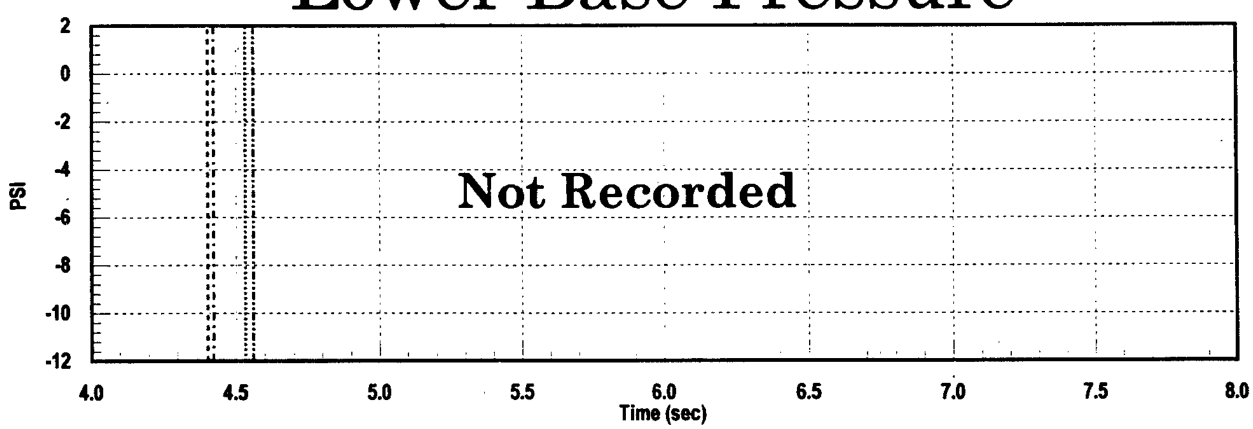
Windblast Deflector Static Pressure



Upper Base Pressure



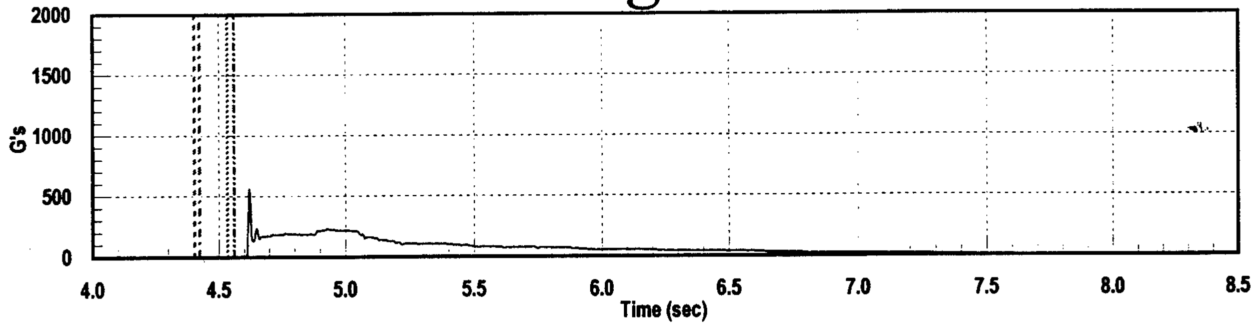
Lower Base Pressure



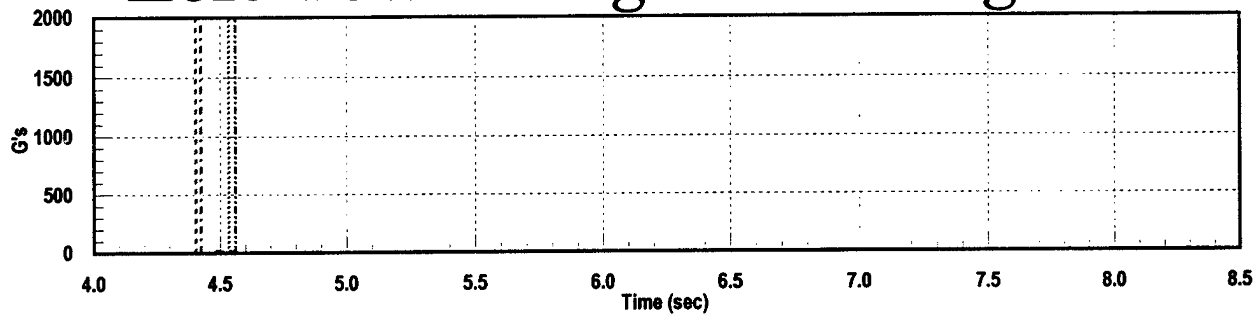
A-15

FL110005, 545 KEAS, 19,000 Ft

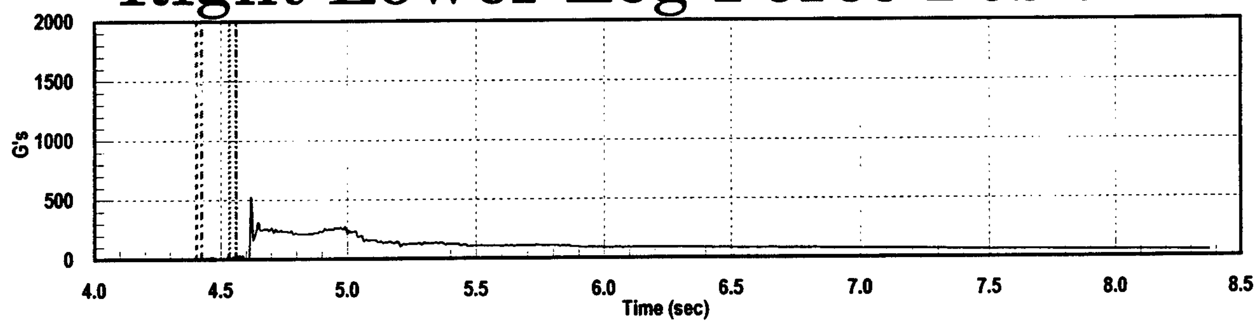
Left Lower Leg Force Positive



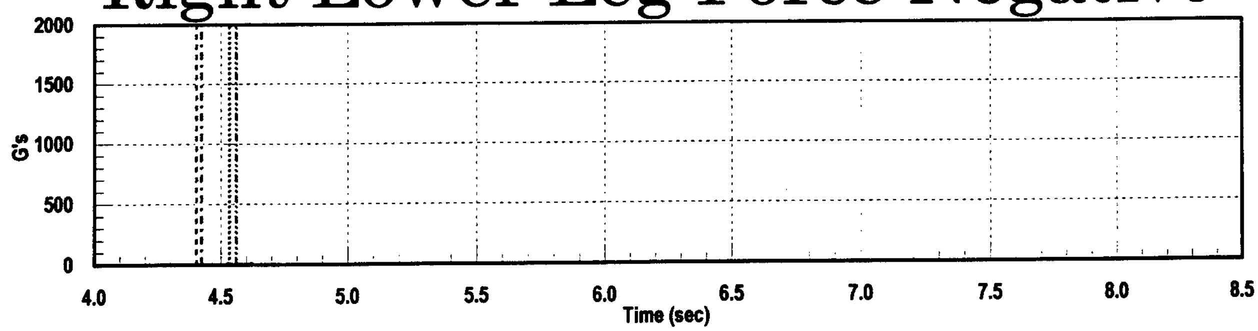
Left Lower Leg Force Negative



Right Lower Leg Force Positive



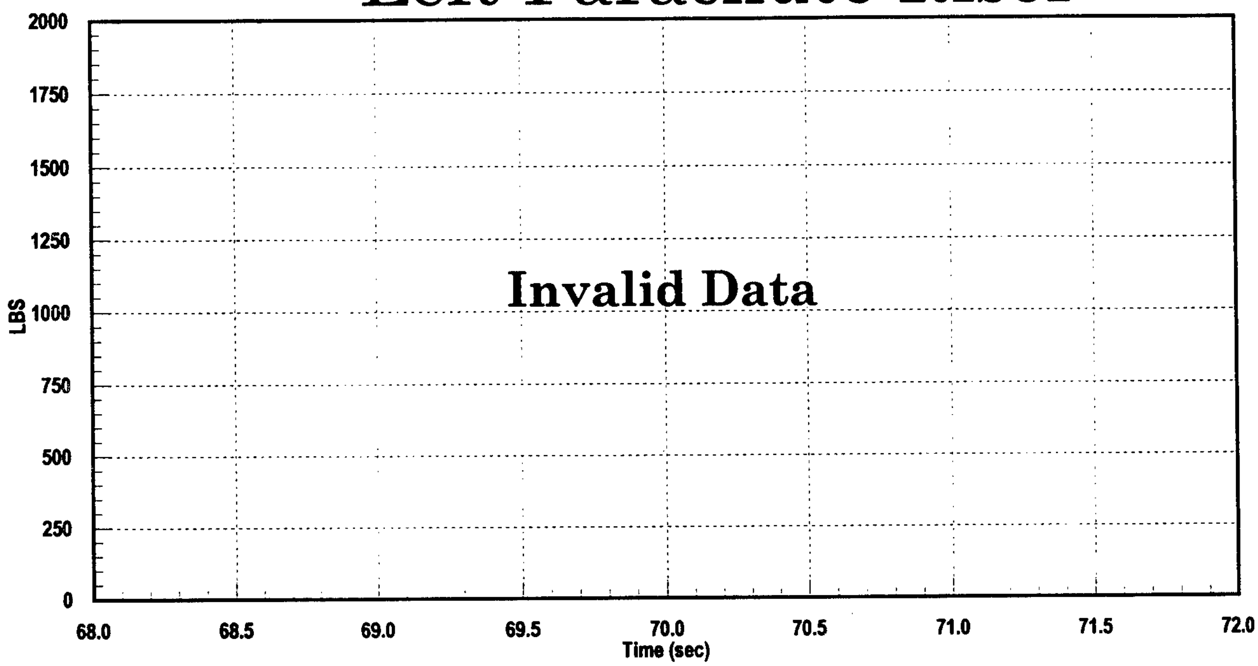
Right Lower Leg Force Negative



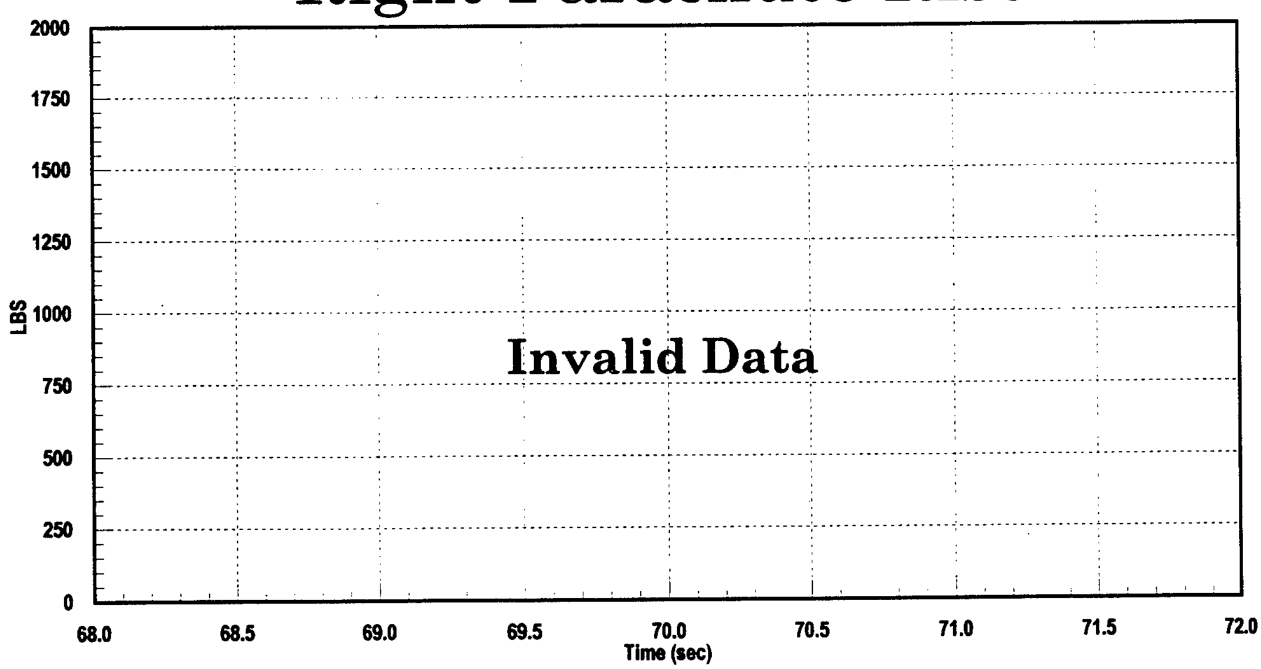
A-16

FL110005, 545 KEAS, 19,000 Ft

Left Parachute Riser



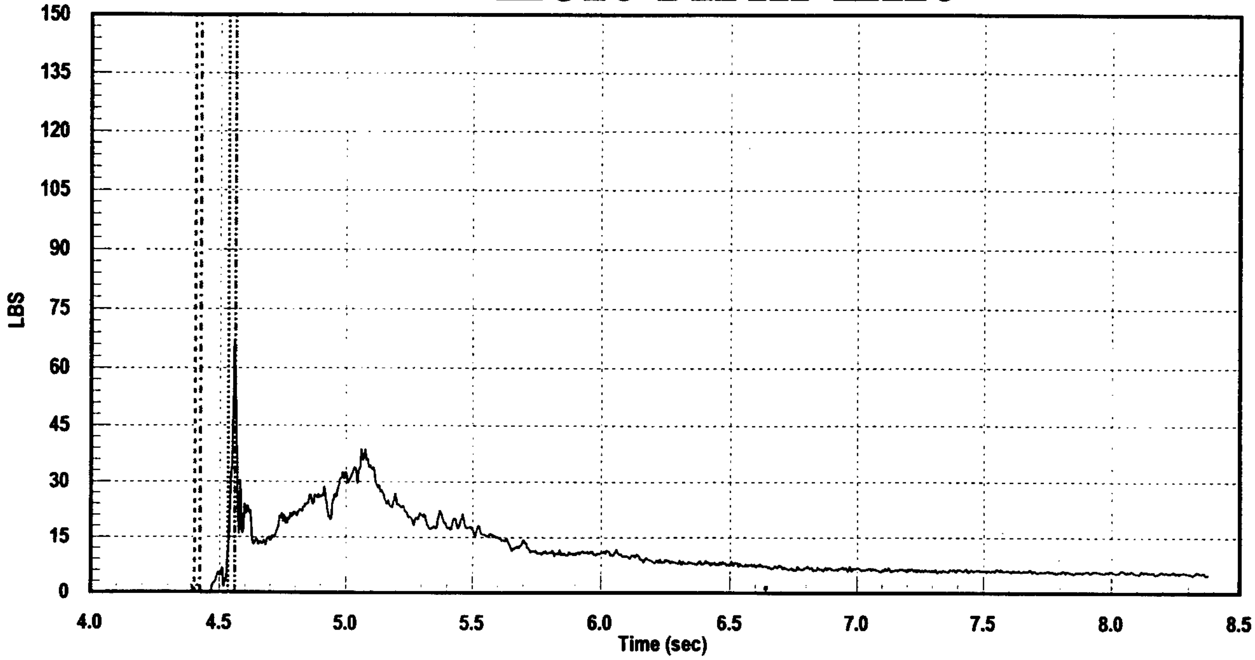
Right Parachute Riser



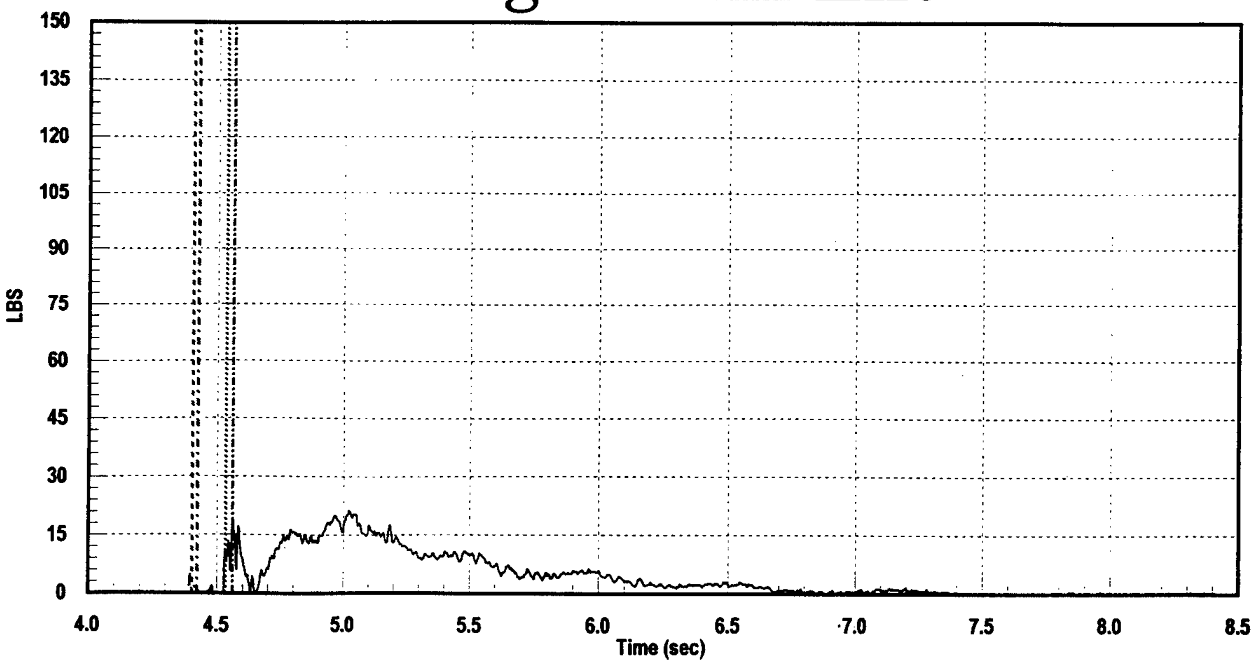
A-17

FL110005, 545 KEAS, 19,000 Ft

Left Arm Lift



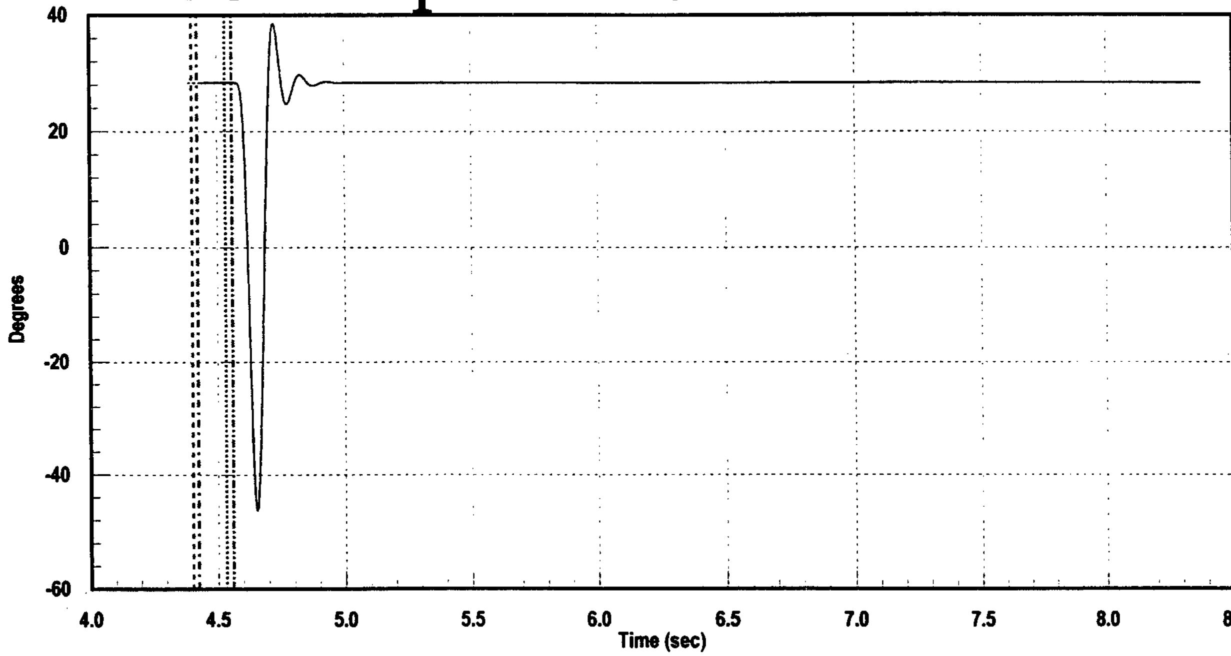
Right Arm Lift



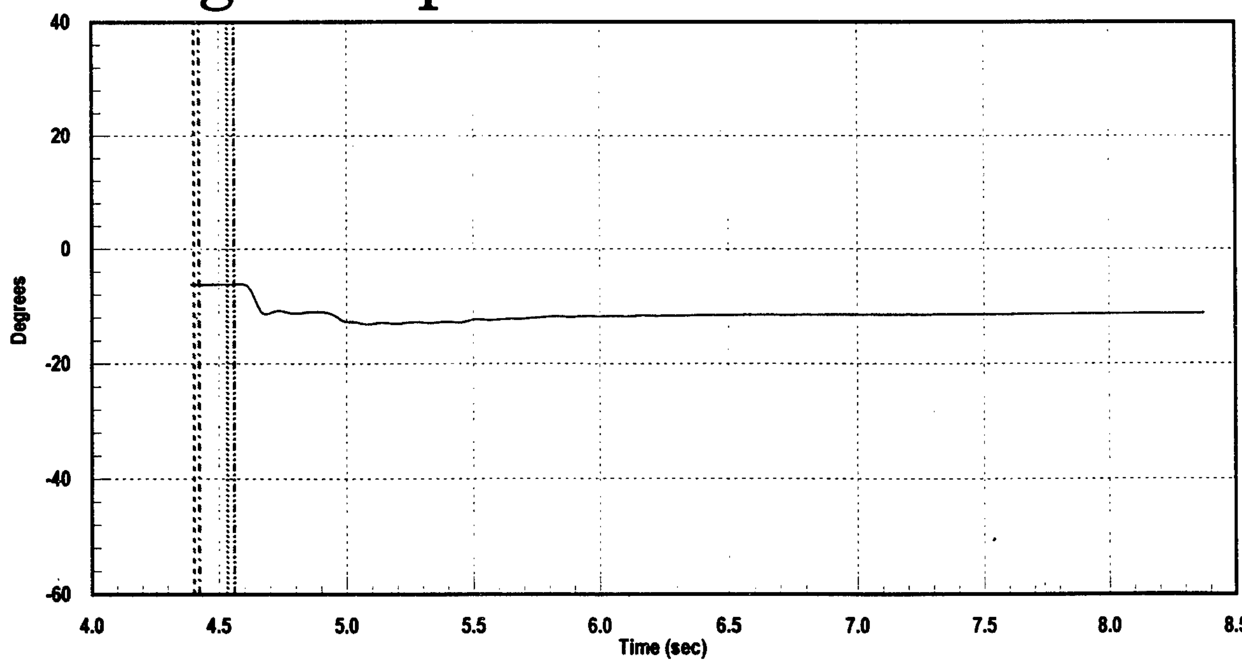
A-18

FL110005, 545 KEAS, 19,000 Ft

Left Hip Abduction/Adduction



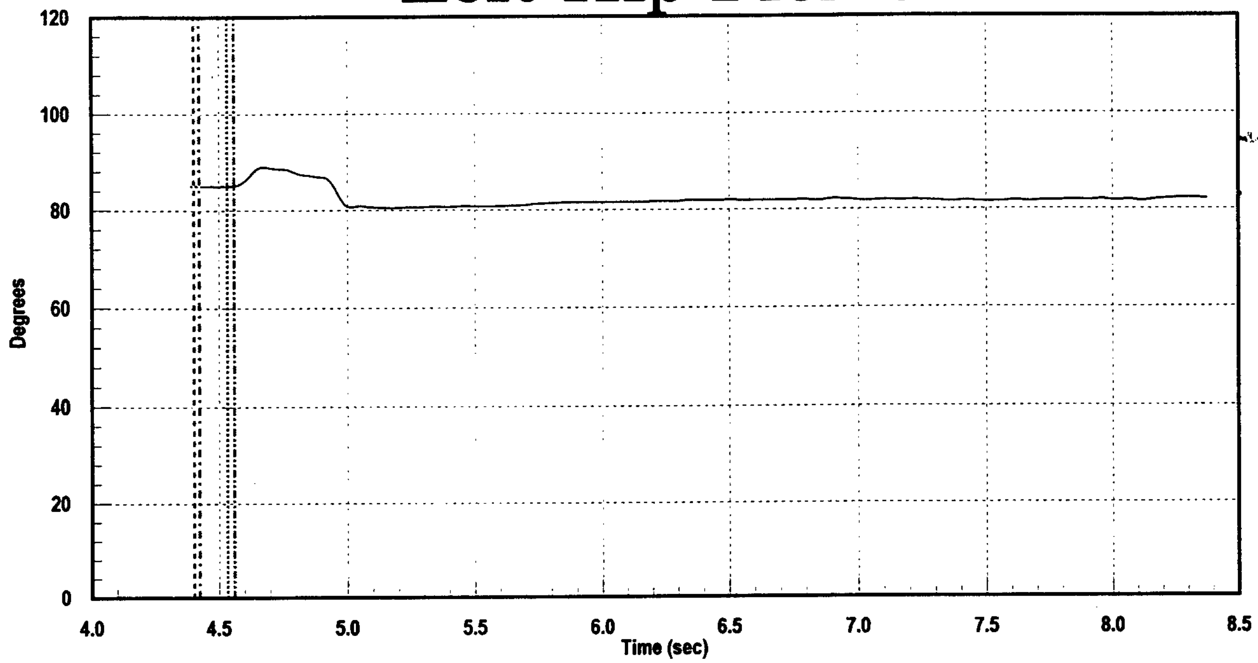
Right Hip Abduction/Adduction



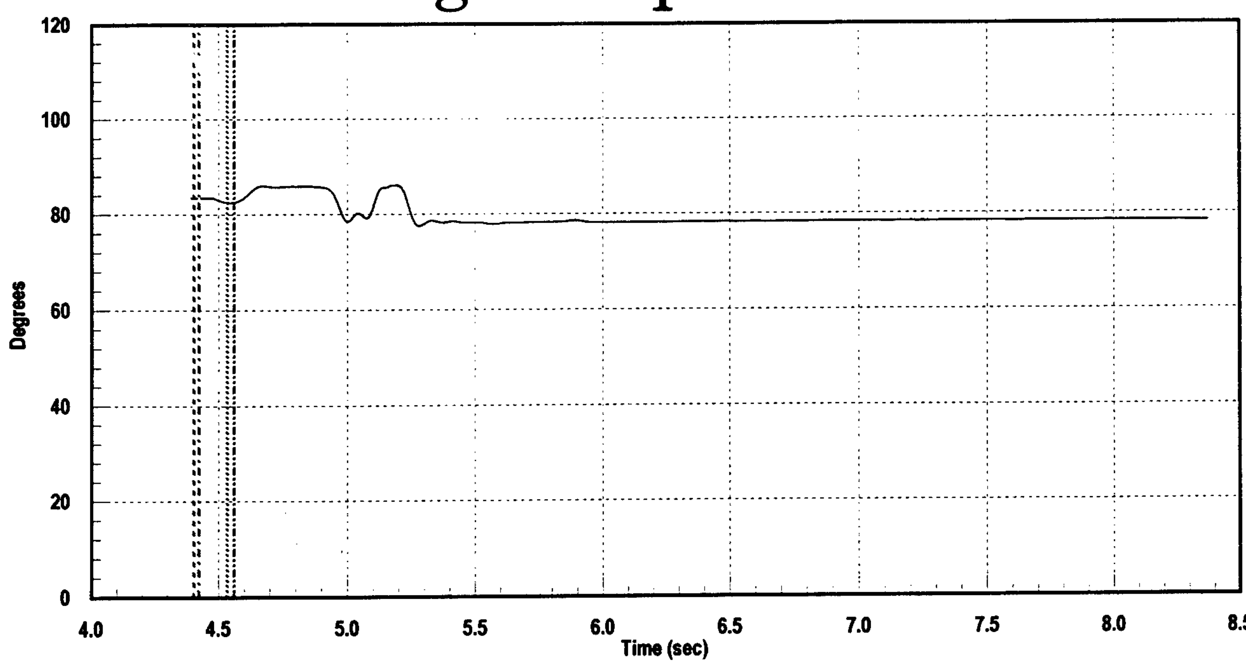
A-19

FL110005, 545 KEAS, 19,000 Ft

Left Hip Flexion



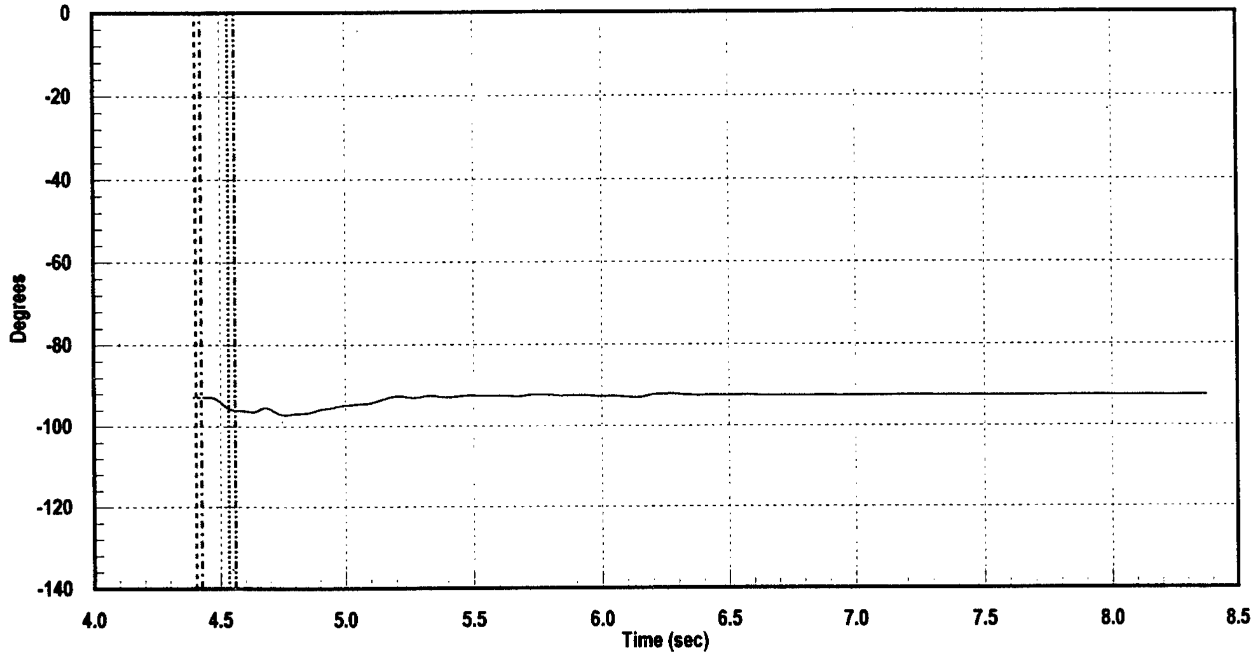
Right Hip Flexion



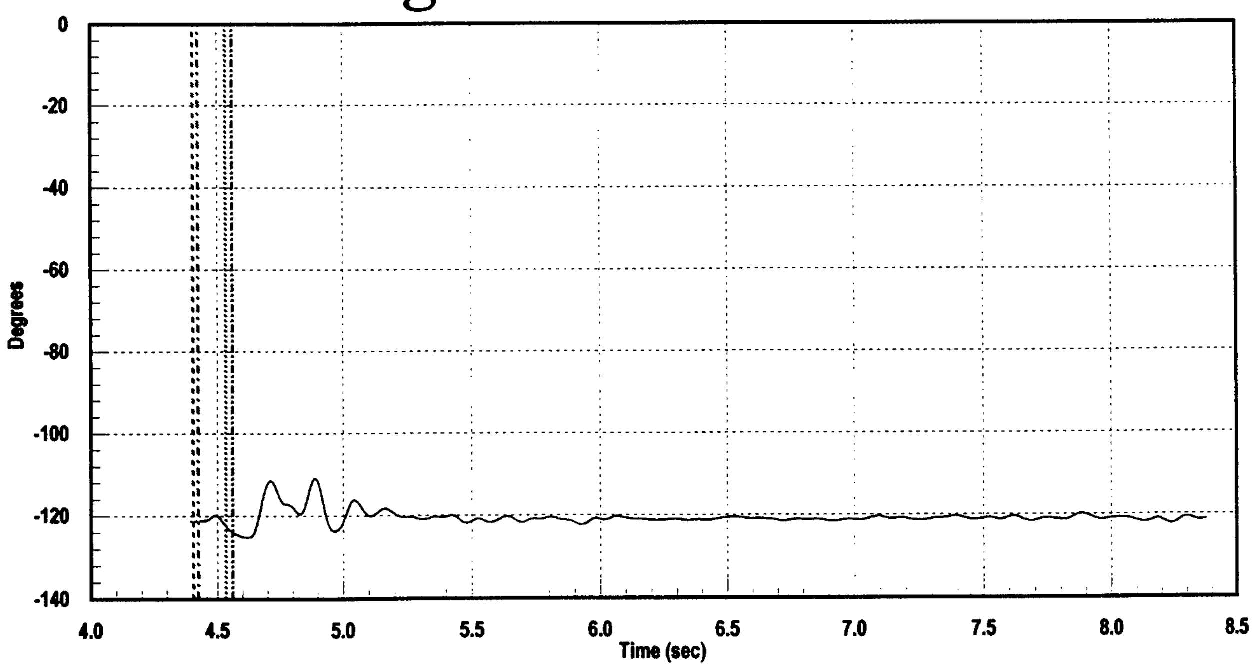
A-20

FL110005, 545 KEAS, 19,000 Ft

Left Knee Flexion



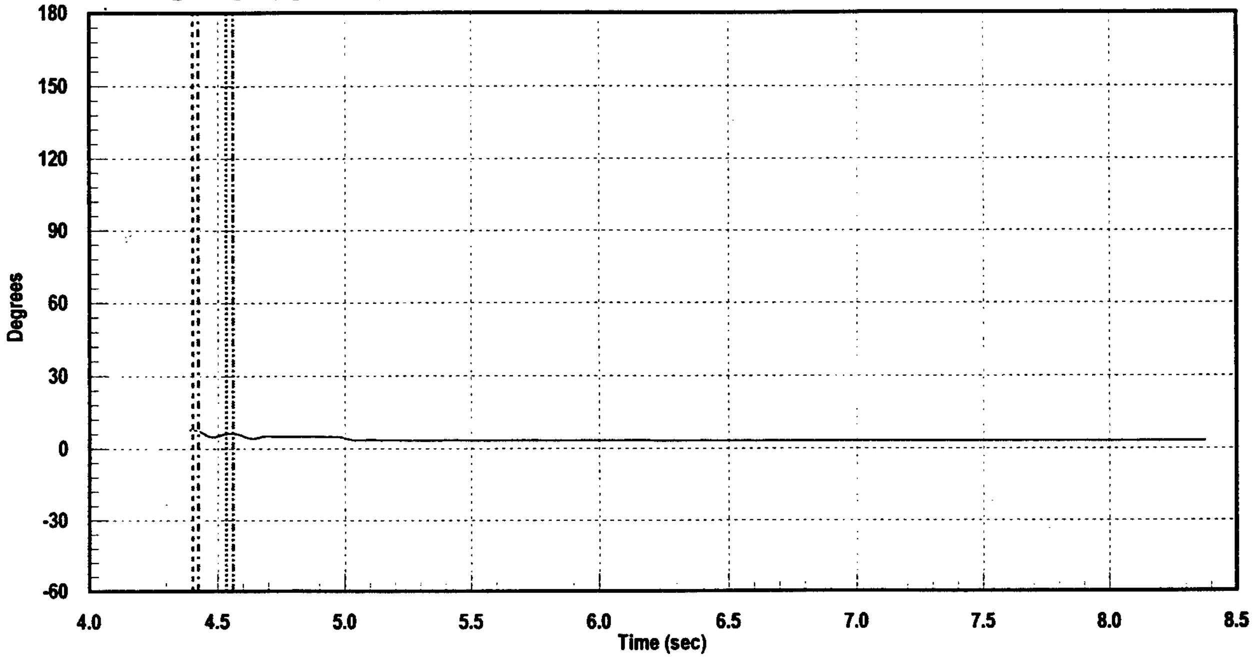
Right Knee Flexion



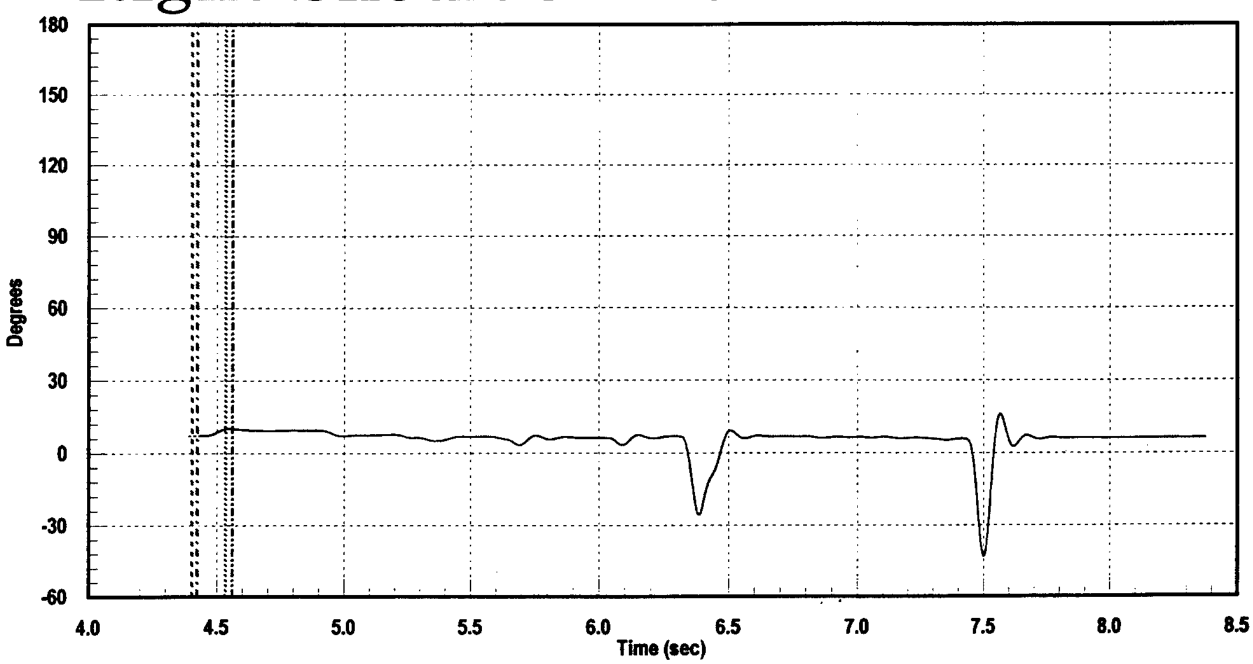
A-21

FL110005, 545 KEAS, 19,000 Ft

Left Shoulder Flexion/Extenstion



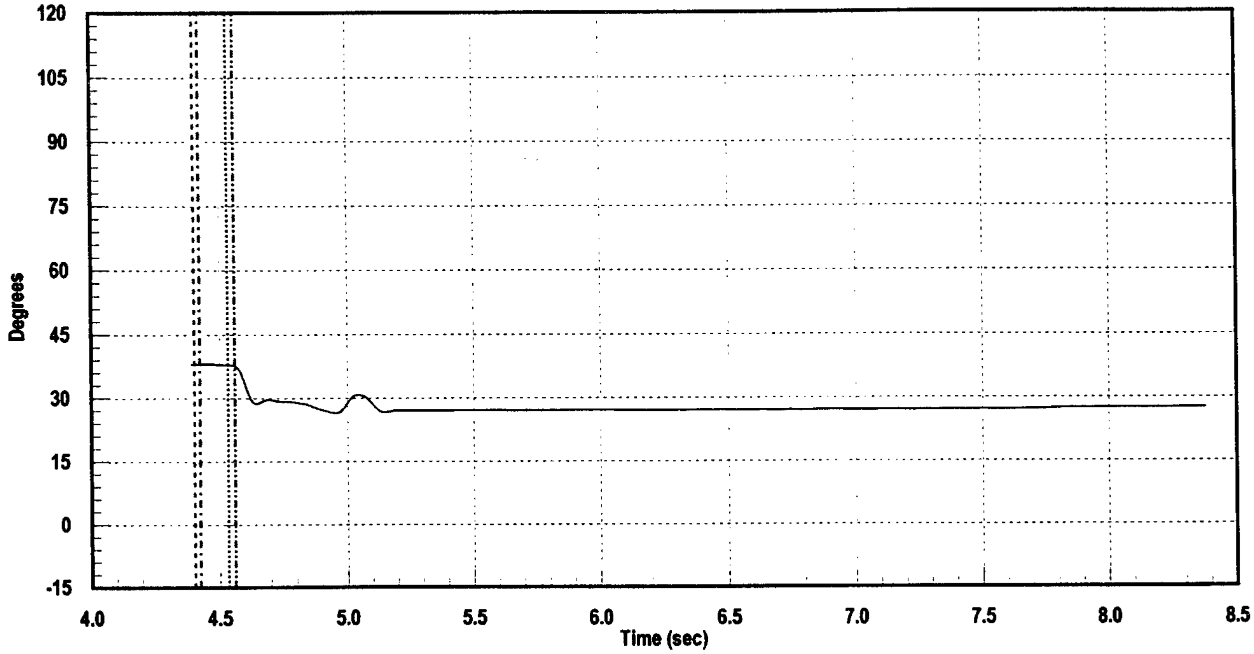
Right Shoulder Flexion/Extension



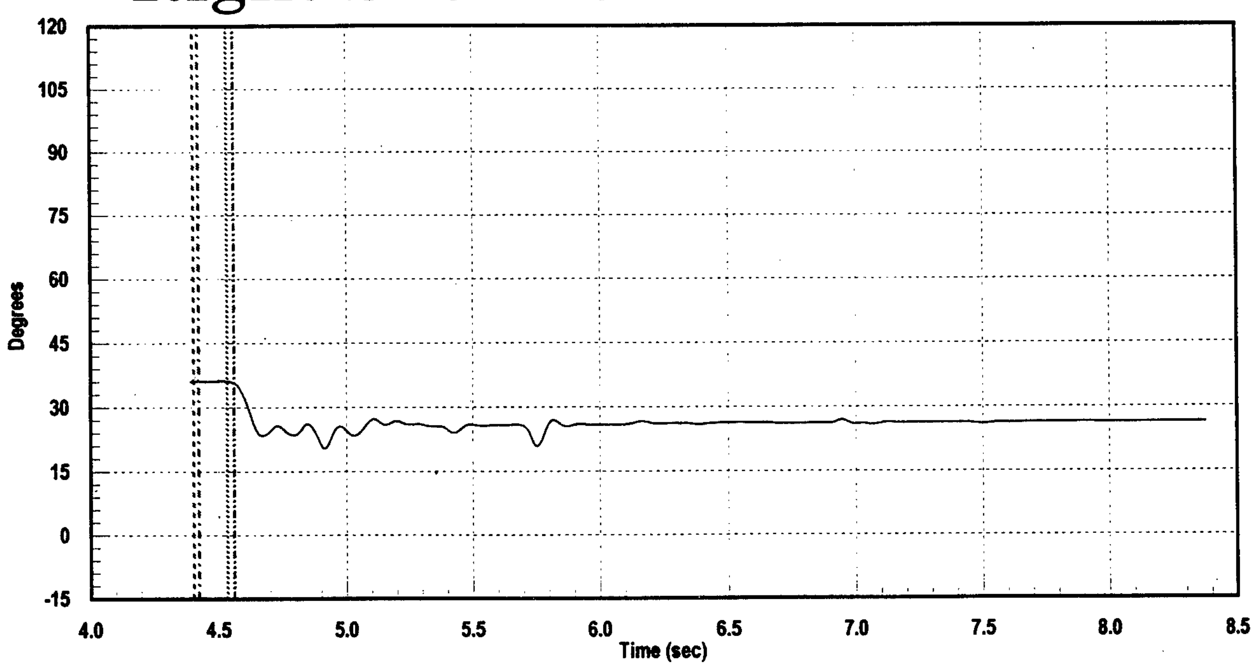
A-22

FL110005, 545 KEAS, 19,000 Ft

Left Shoulder Medial/Lateral



Right Shoulder Medial/Lateral



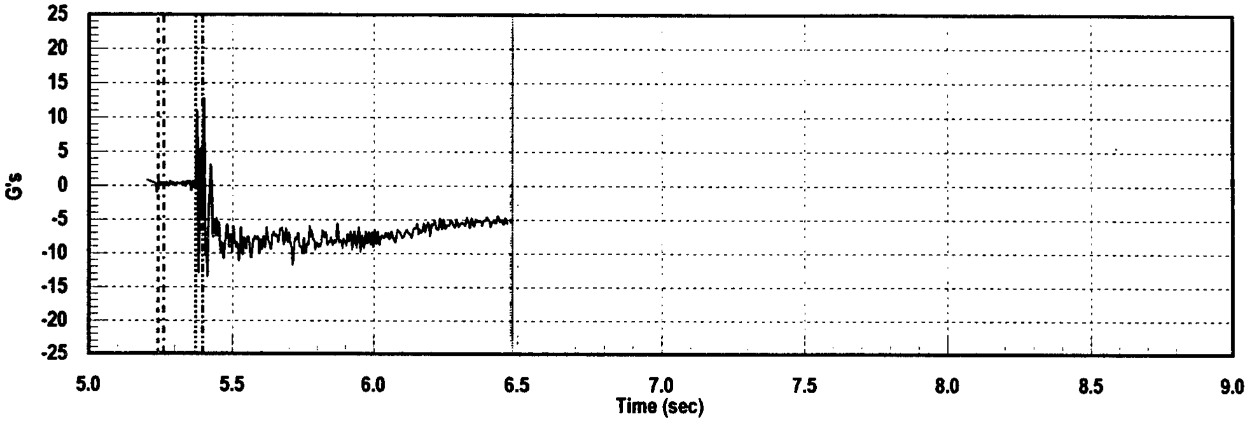
A-23

FL083301, 450 KEAS, 1,200 Ft
Processed Data

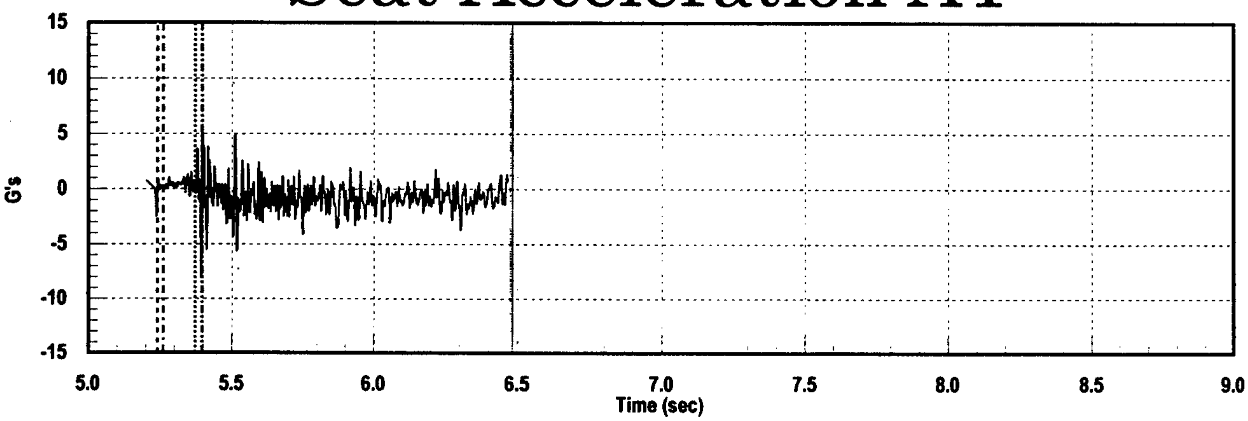
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL083301, 450 KEAS, 1,200 Ft

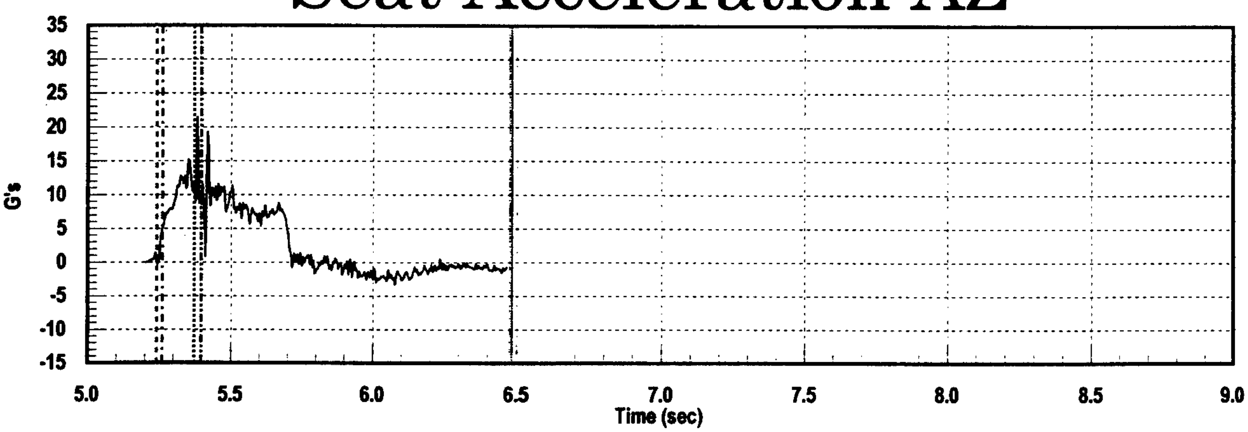
Seat Acceleration AX



Seat Acceleration AY



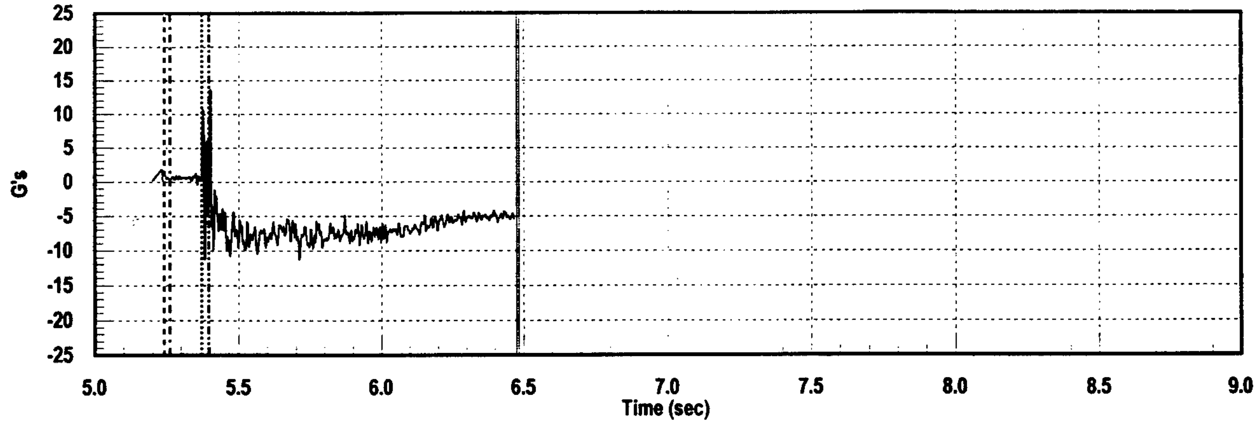
Seat Acceleration AZ



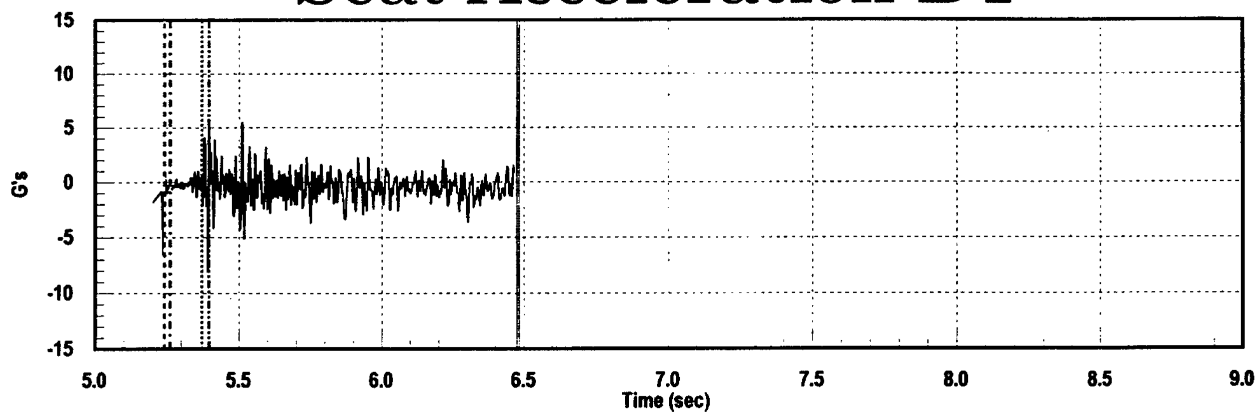
A-1

FL083301, 450 KEAS, 1,200 Ft

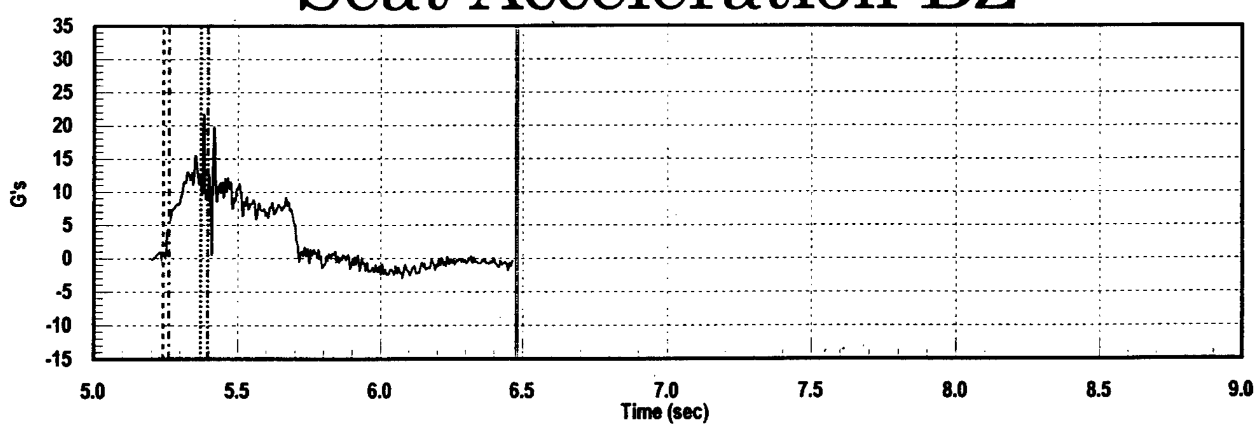
Seat Acceleration BX



Seat Acceleration BY



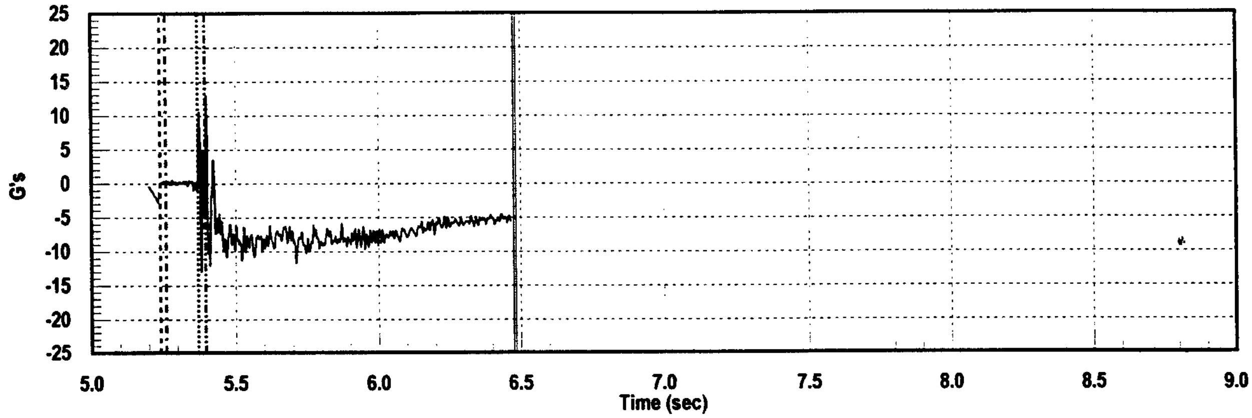
Seat Acceleration BZ



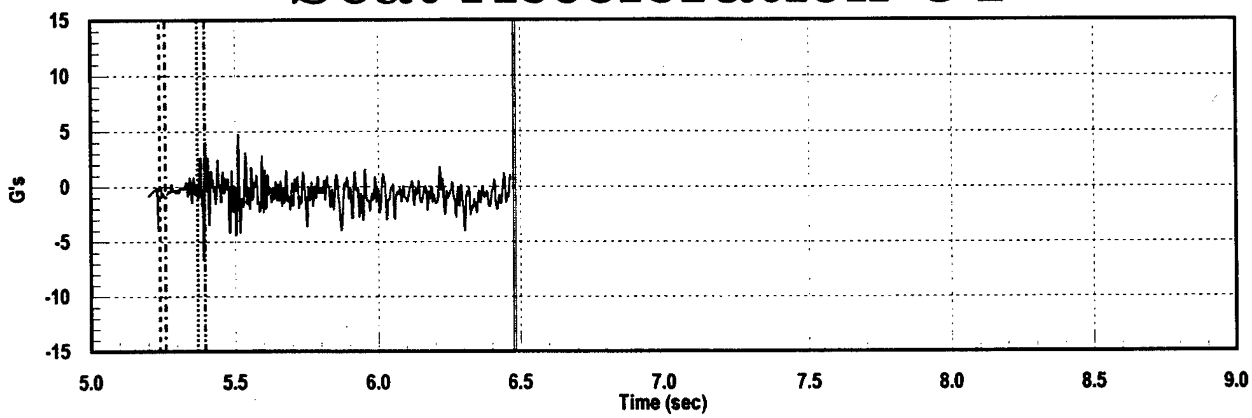
A-2

FL083301, 450 KEAS, 1,200 Ft

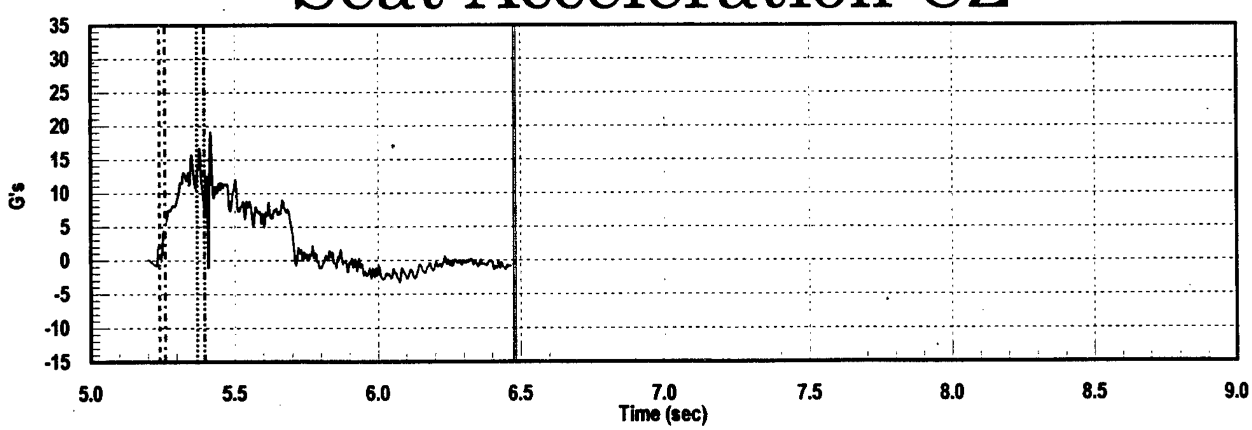
Seat Acceleration CX



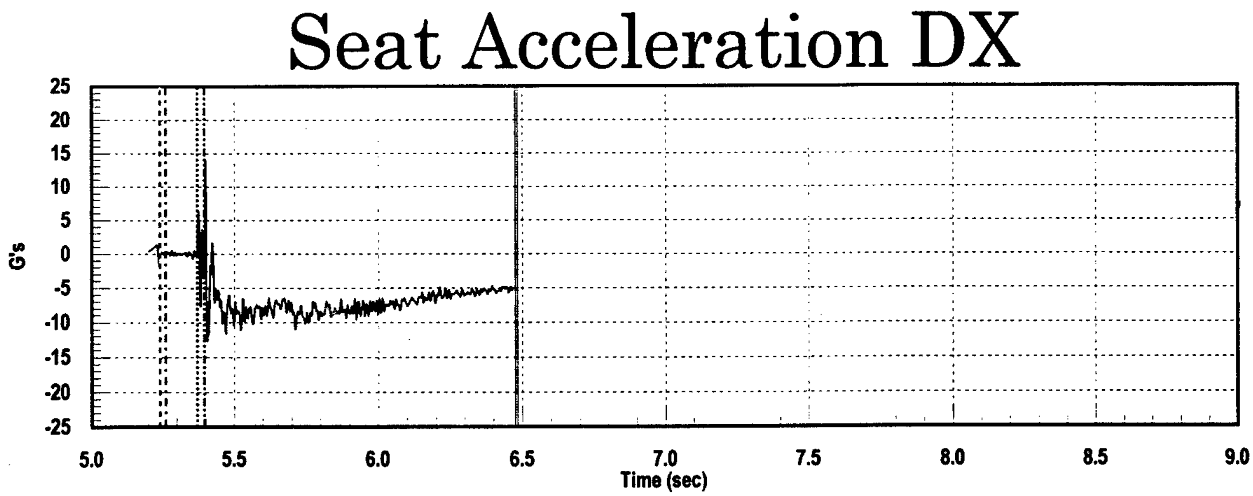
Seat Acceleration CY

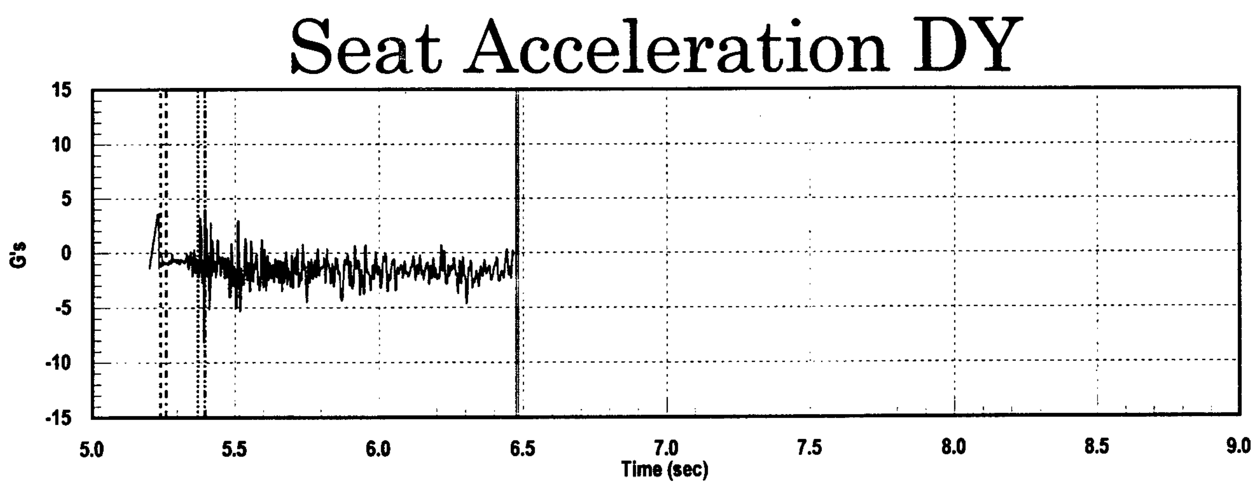


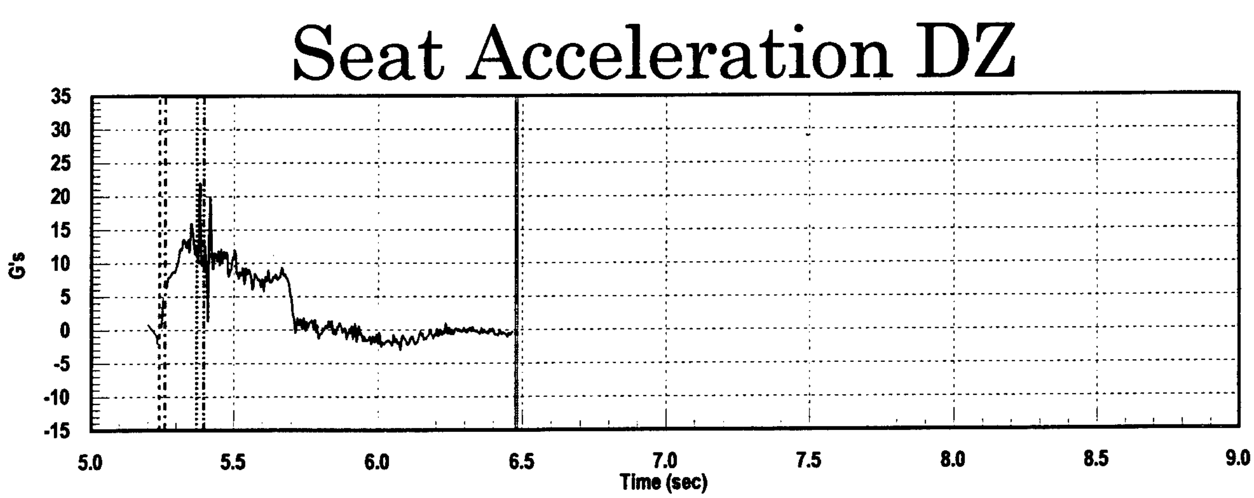
Seat Acceleration CZ



FL083301, 450 KEAS, 1,200 Ft



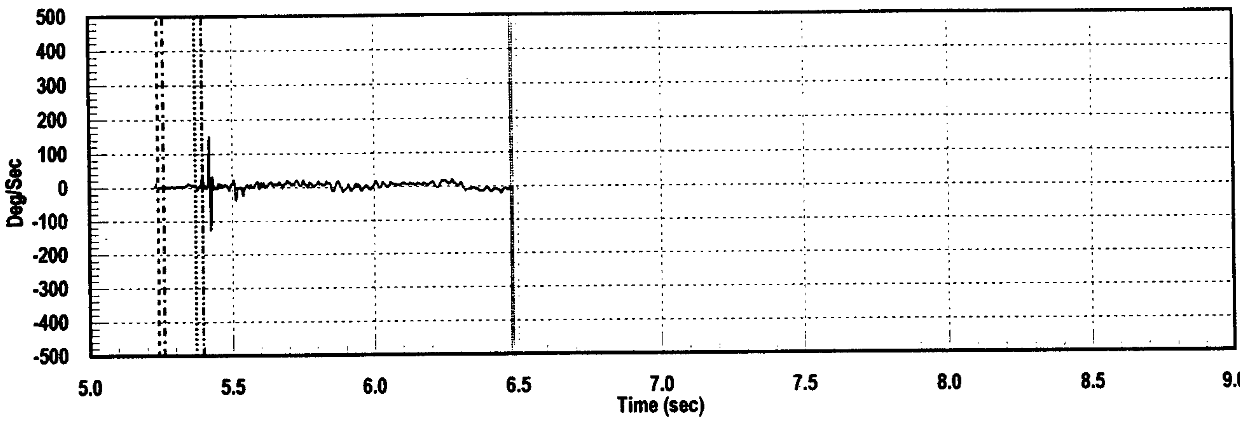




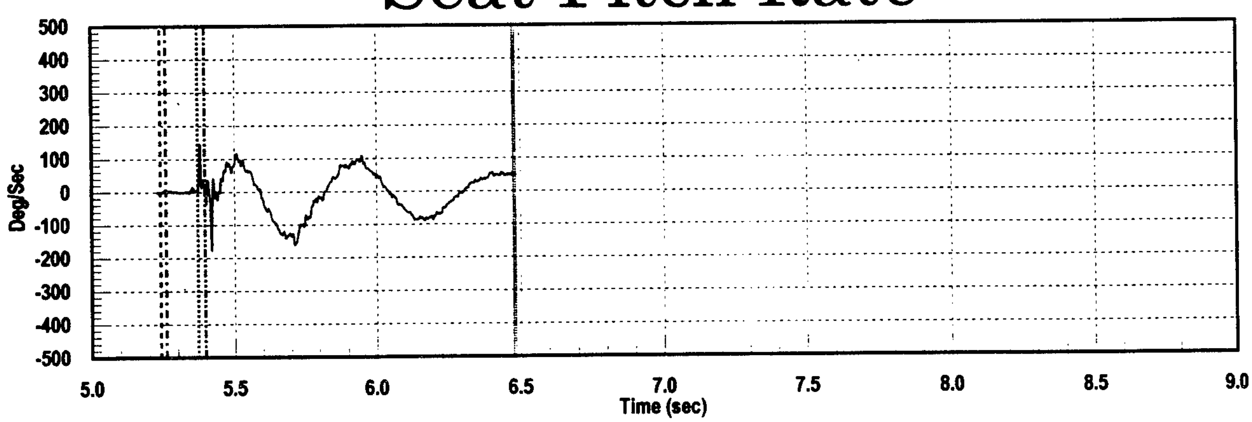
A-4

FL083301, 450 KEAS, 1,200 Ft

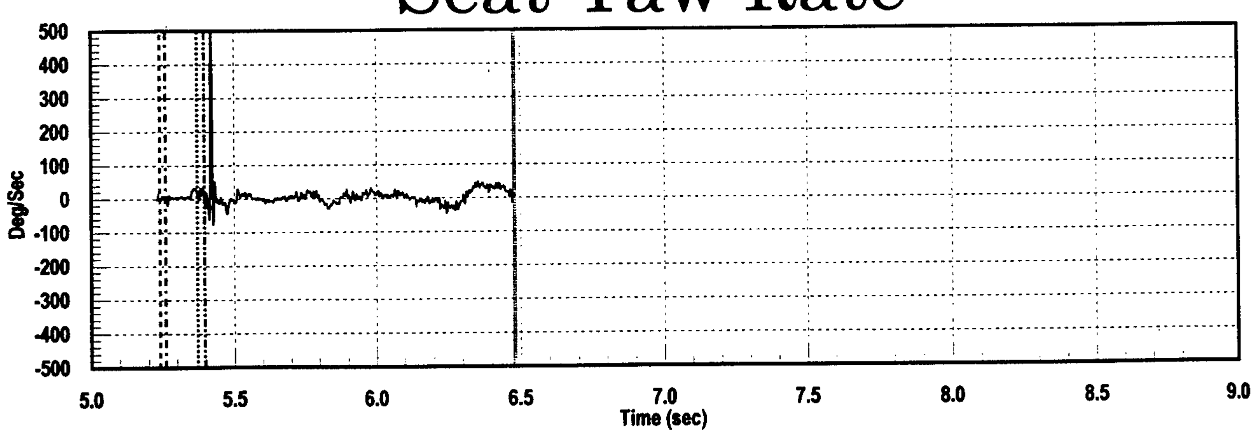
Seat Roll Rate



Seat Pitch Rate



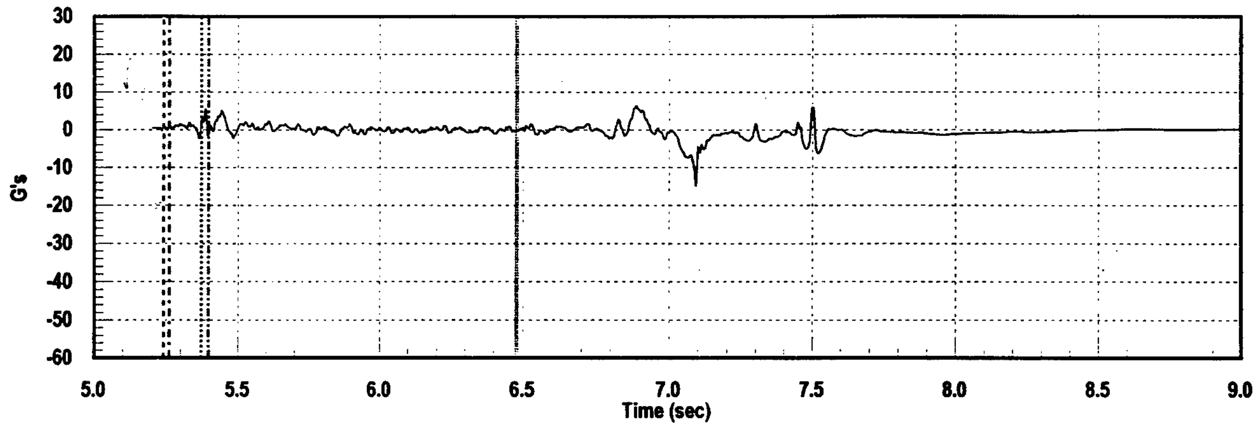
Seat Yaw Rate



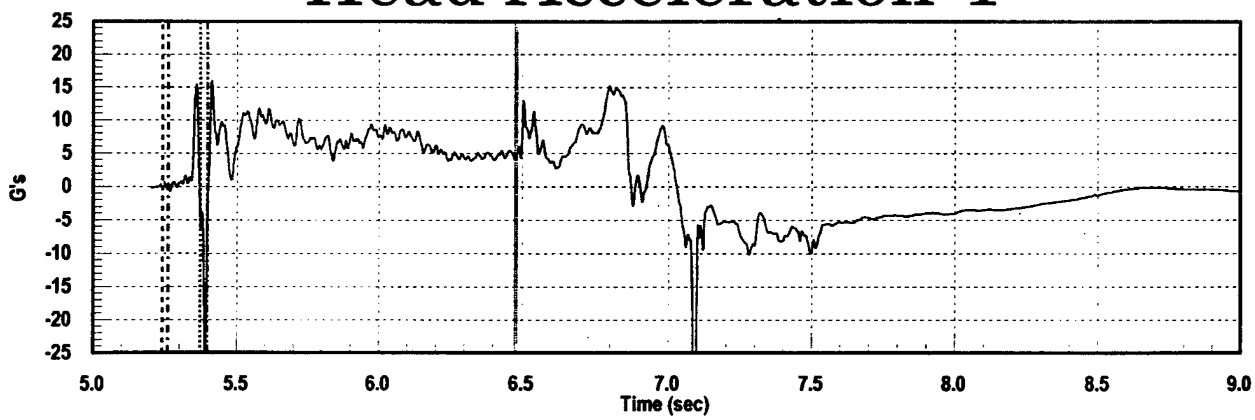
A-5

FL083301, 450 KEAS, 1,200 Ft

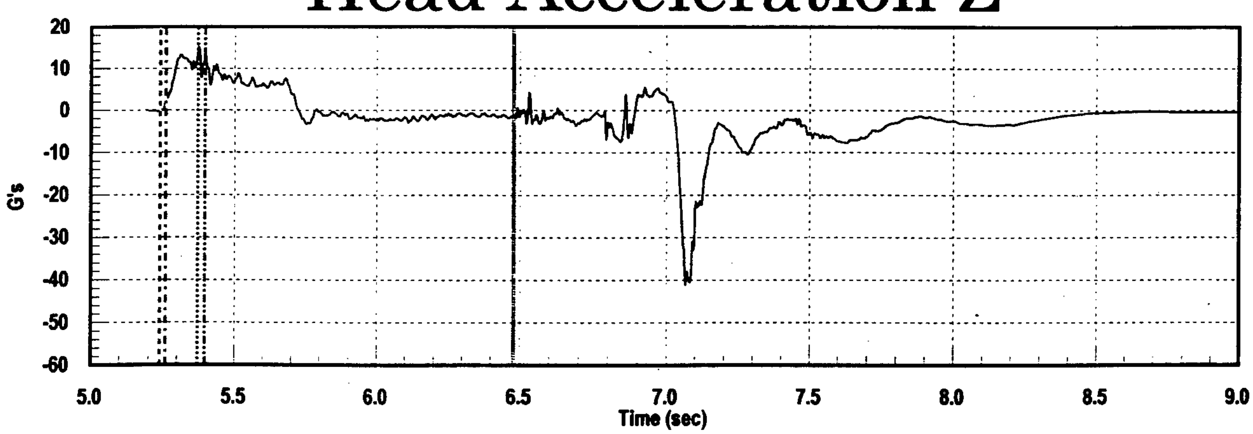
Head Acceleration X



Head Acceleration Y

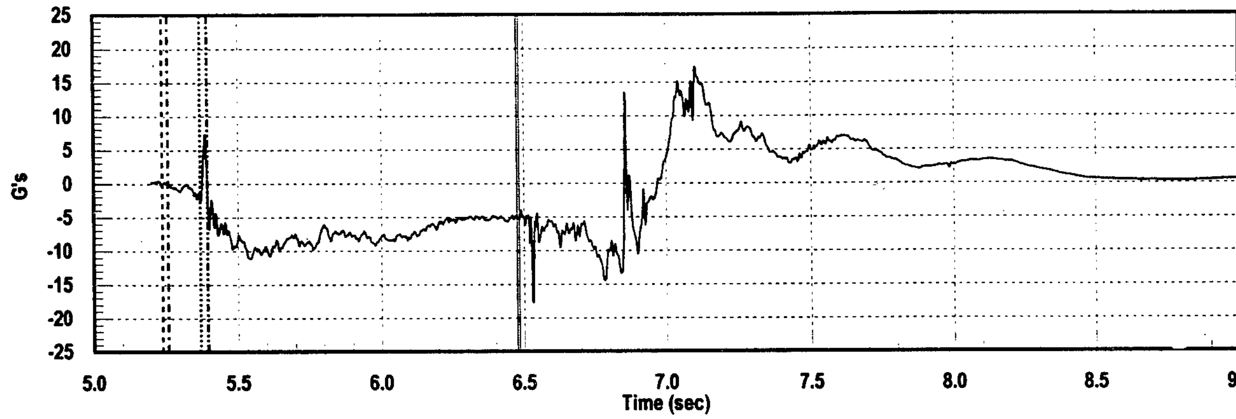


Head Acceleration Z

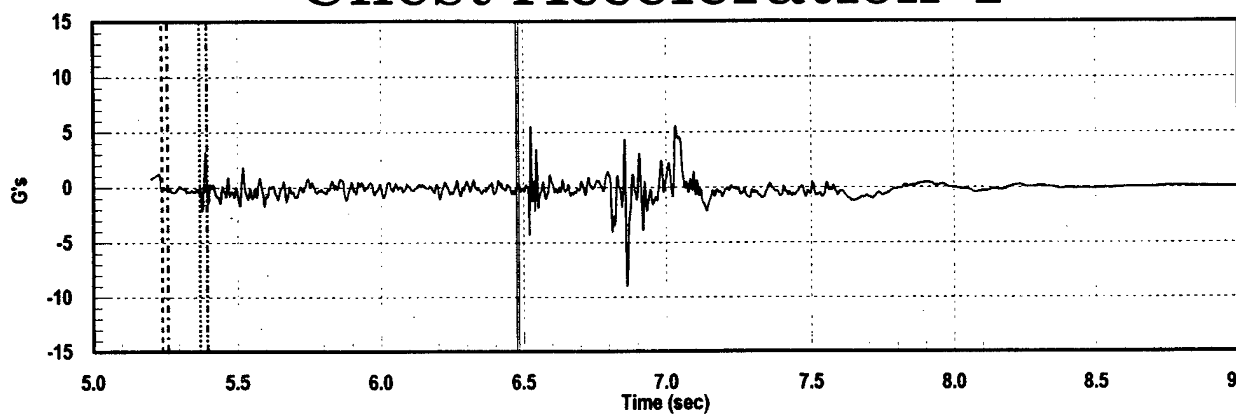


FL083301, 450 KEAS, 1,200 Ft

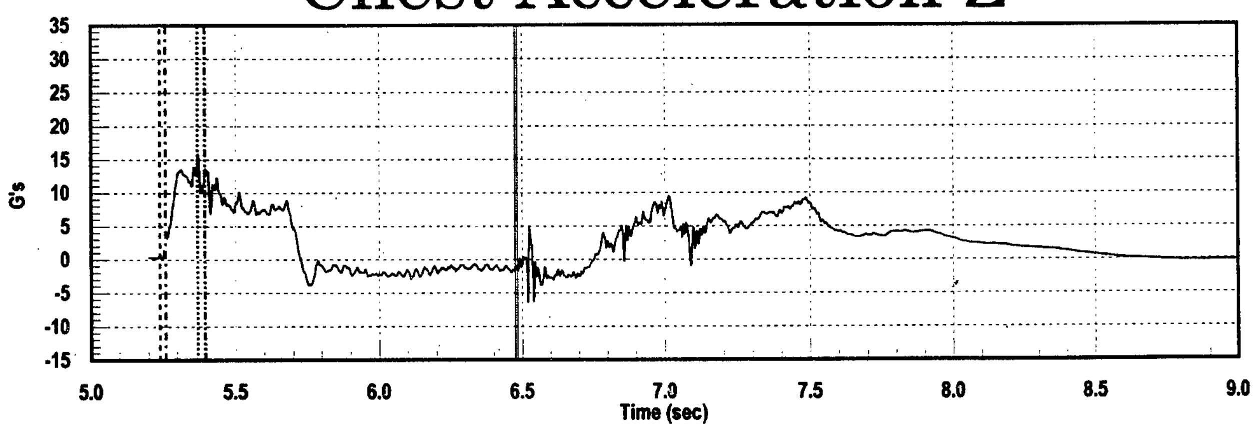
Chest Acceleration X



Chest Acceleration Y



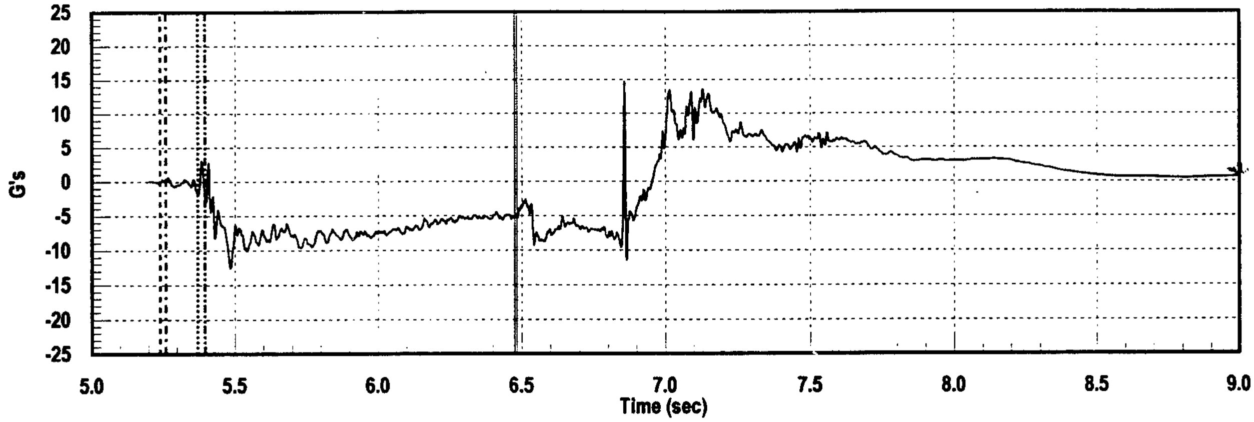
Chest Acceleration Z



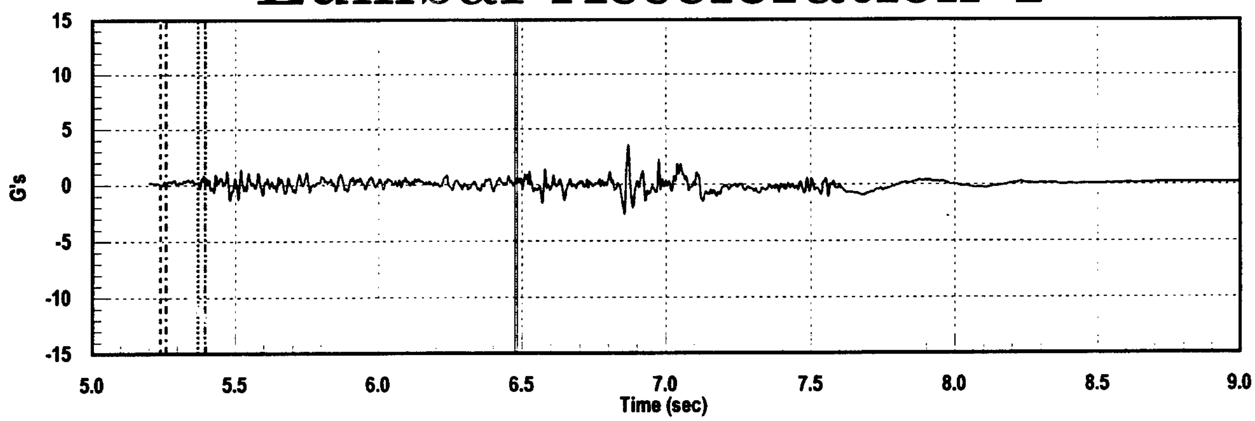
A-7

FL083301, 450 KEAS, 1,200 Ft

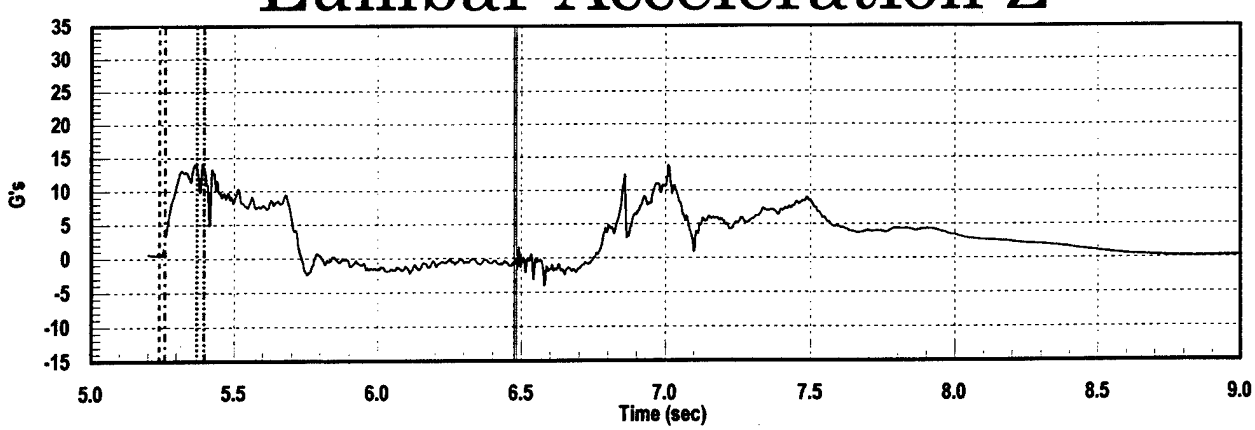
Lumbar Acceleration X



Lumbar Acceleration Y



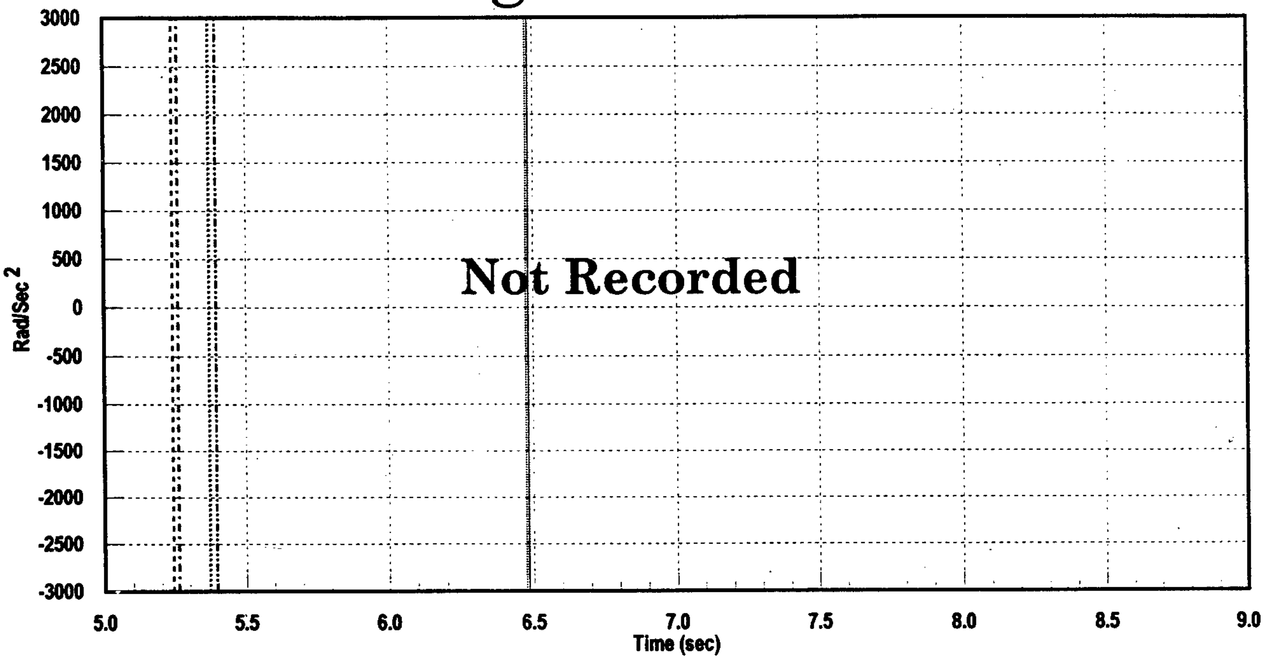
Lumbar Acceleration Z



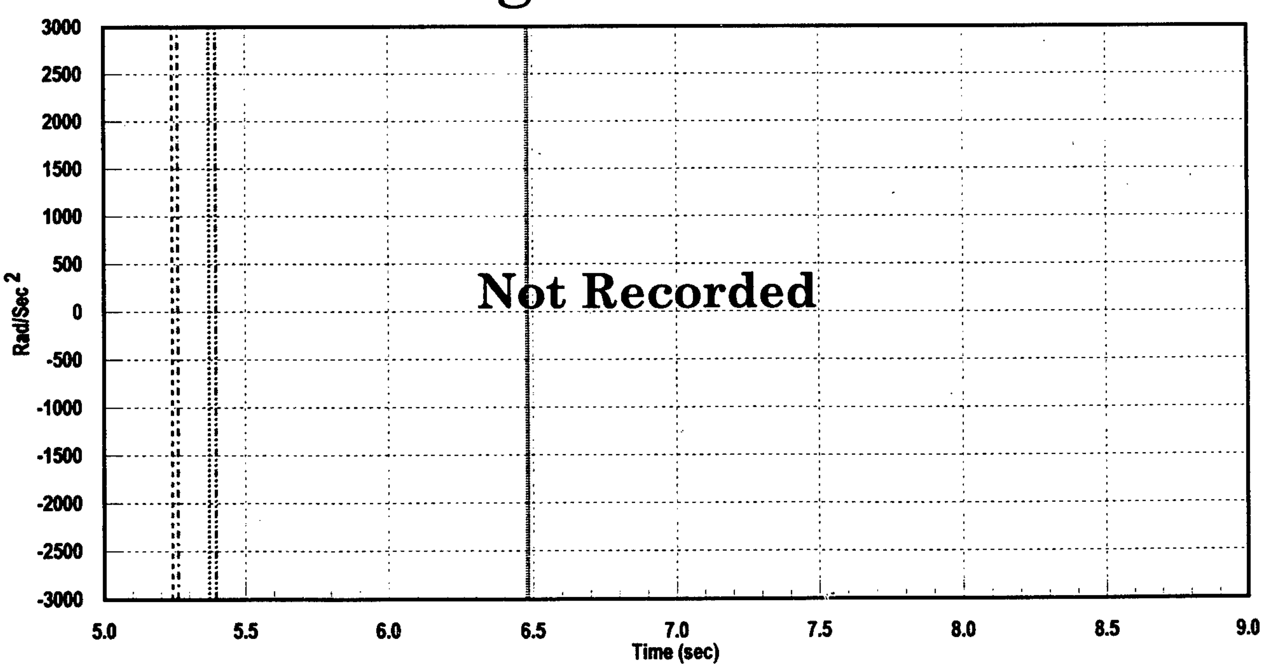
A-8

FL083301, 450 KEAS, 1,200 Ft

Head Angular Acceleration Y



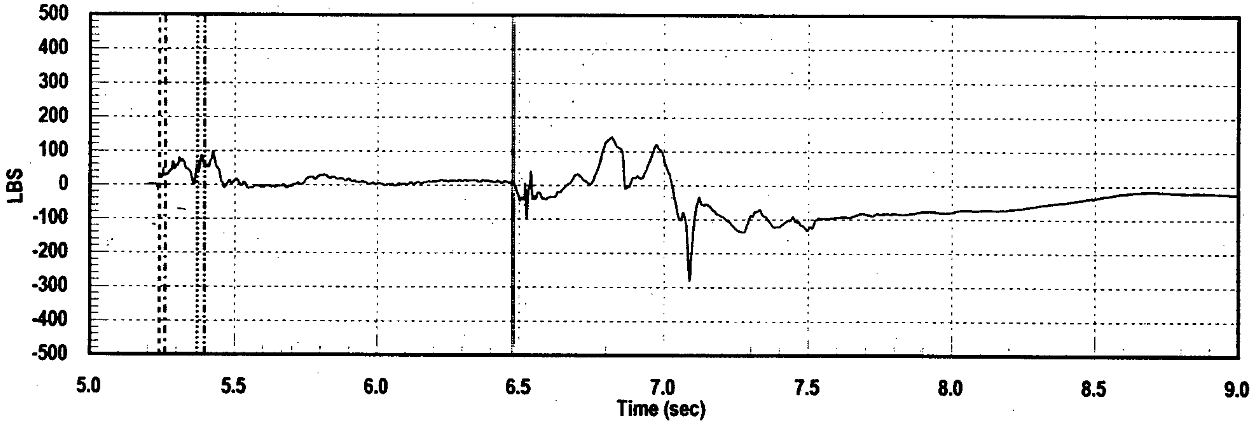
Chest Angular Acceleration Y



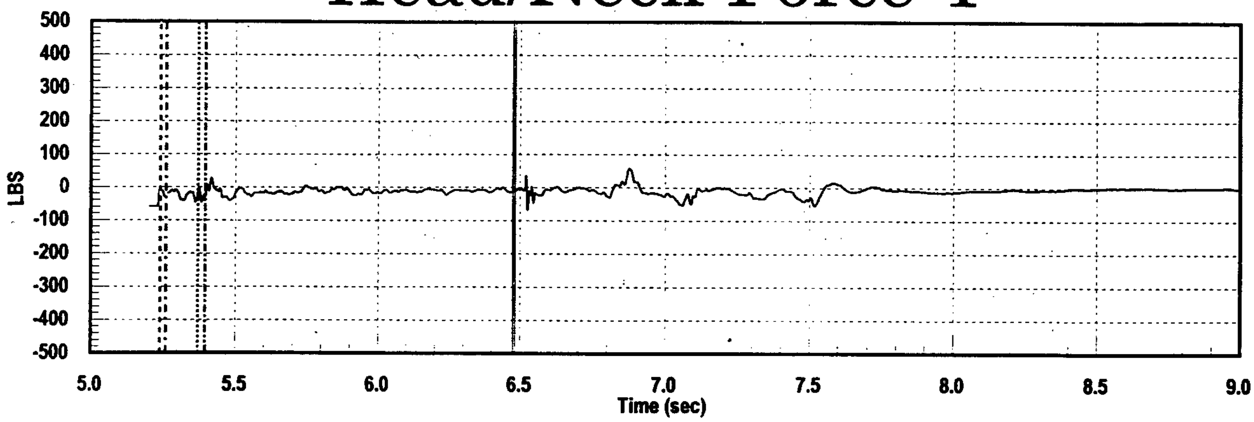
A-9

FL083301, 450 KEAS, 1,200 Ft

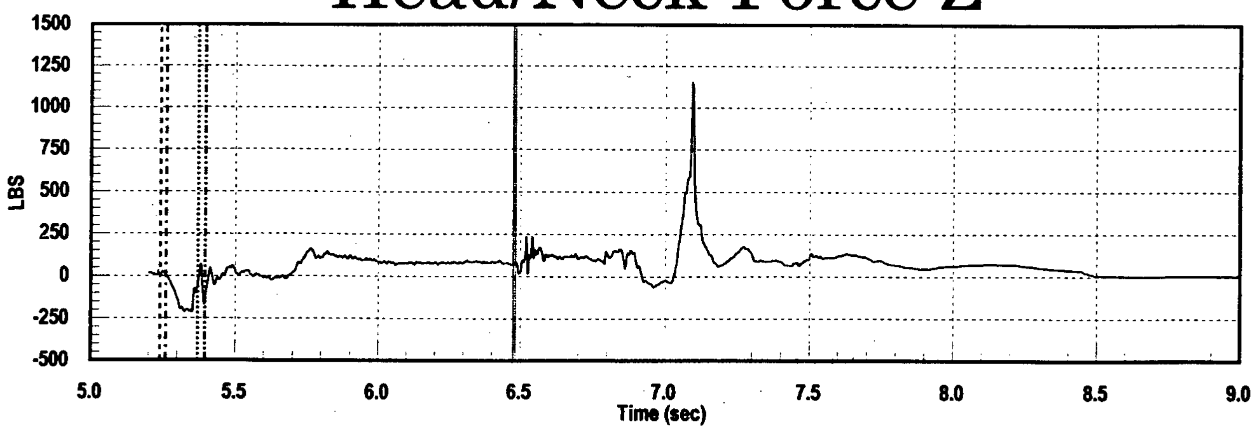
Head/Neck Force X



Head/Neck Force Y



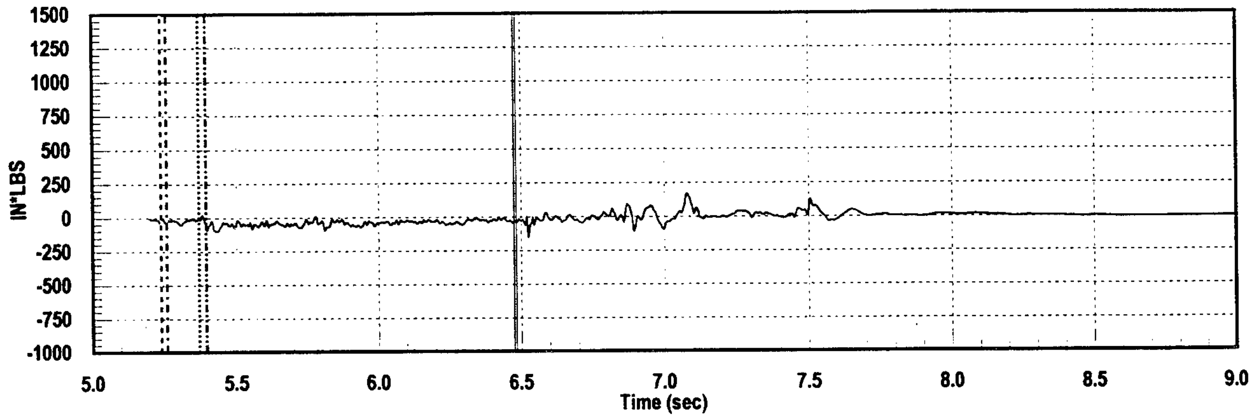
Head/Neck Force Z



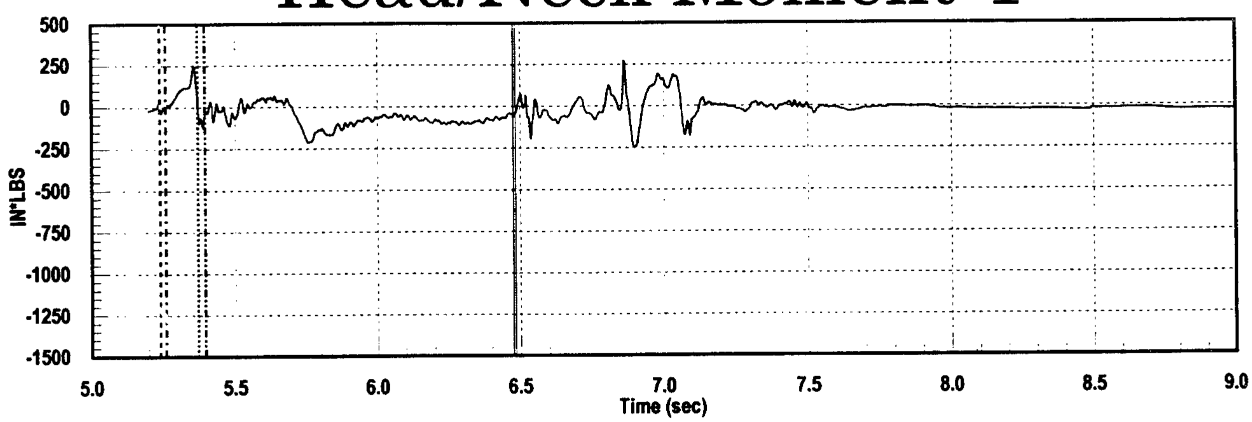
A-10

FL083301, 450 KEAS, 1,200 Ft

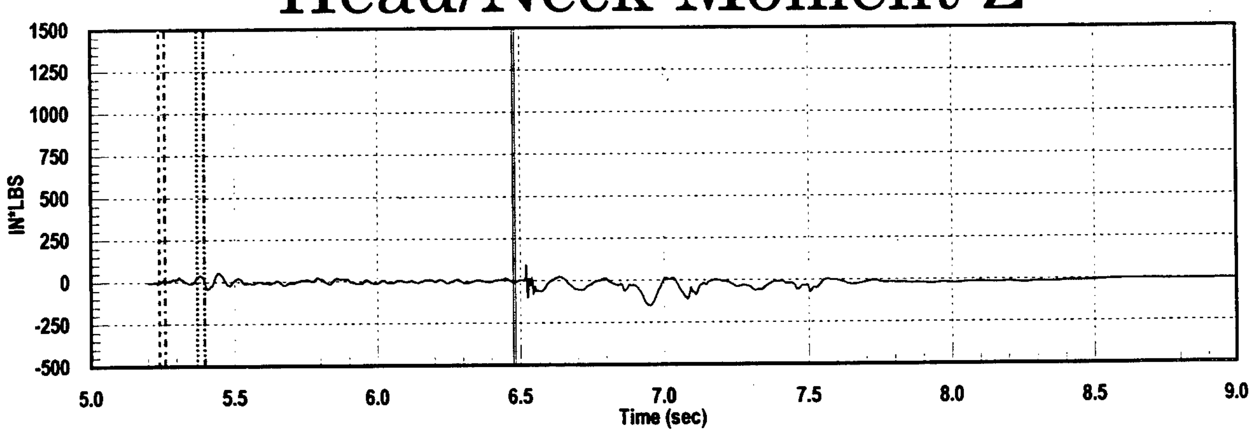
Head/Neck Moment X



Head/Neck Moment Y



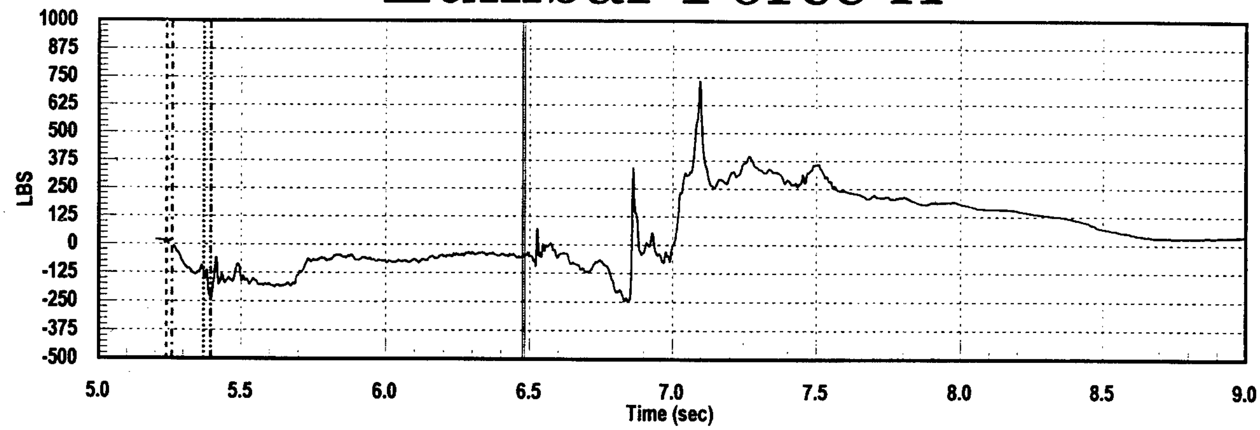
Head/Neck Moment Z



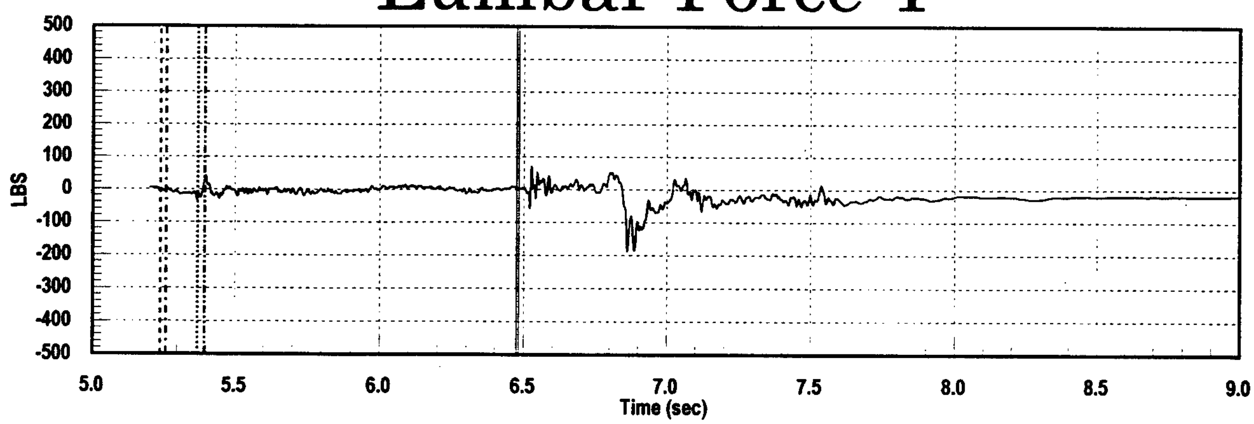
A-11

FL083301, 450 KEAS, 1,200 Ft

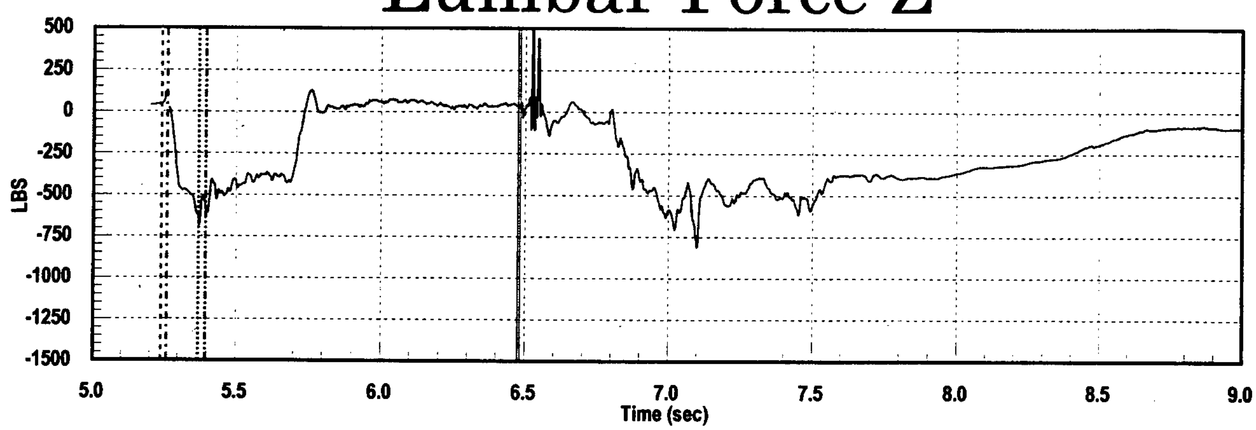
Lumbar Force X



Lumbar Force Y



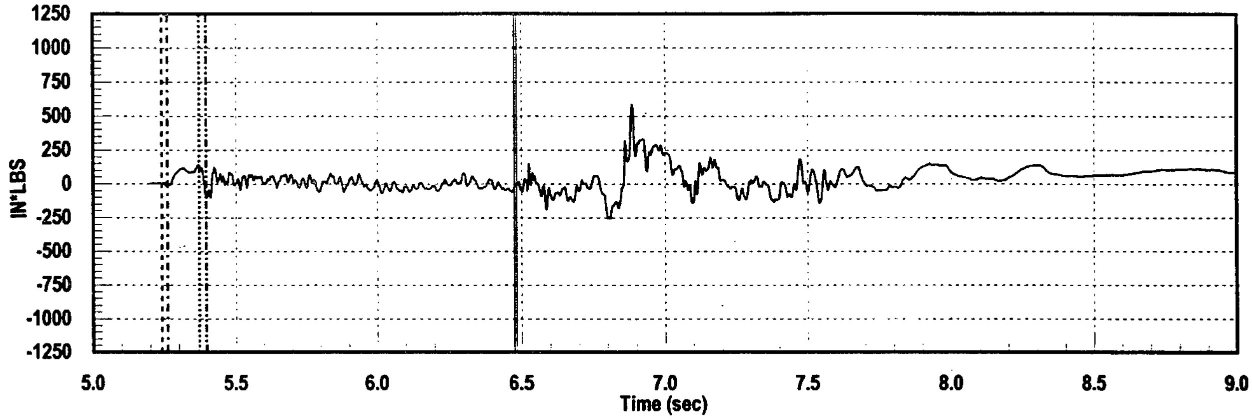
Lumbar Force Z



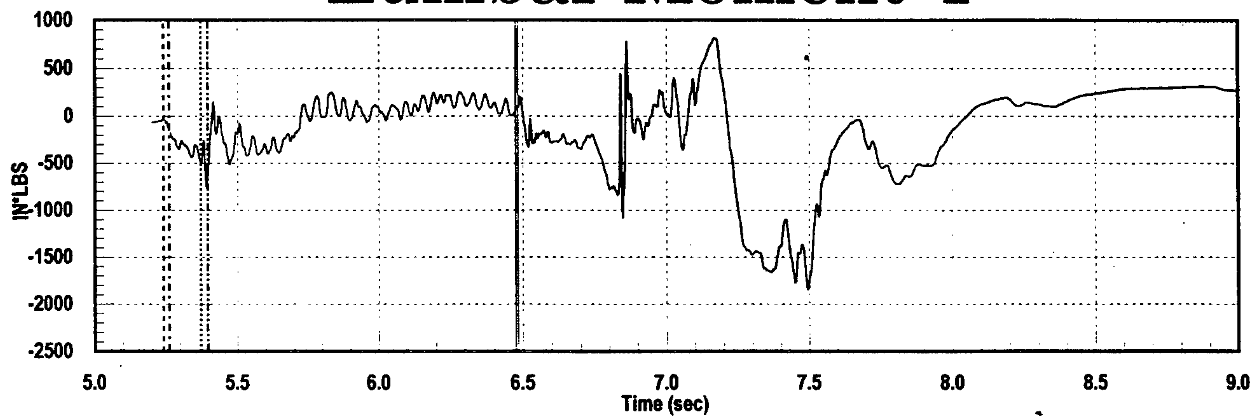
A-12

FL083301, 450 KEAS, 1,200 Ft

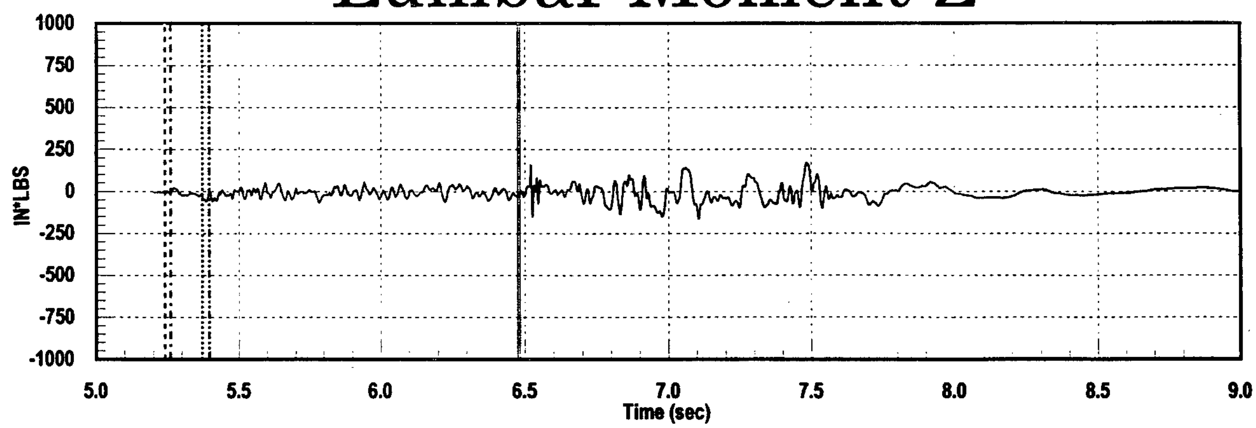
Lumbar Moment X



Lumbar Moment Y



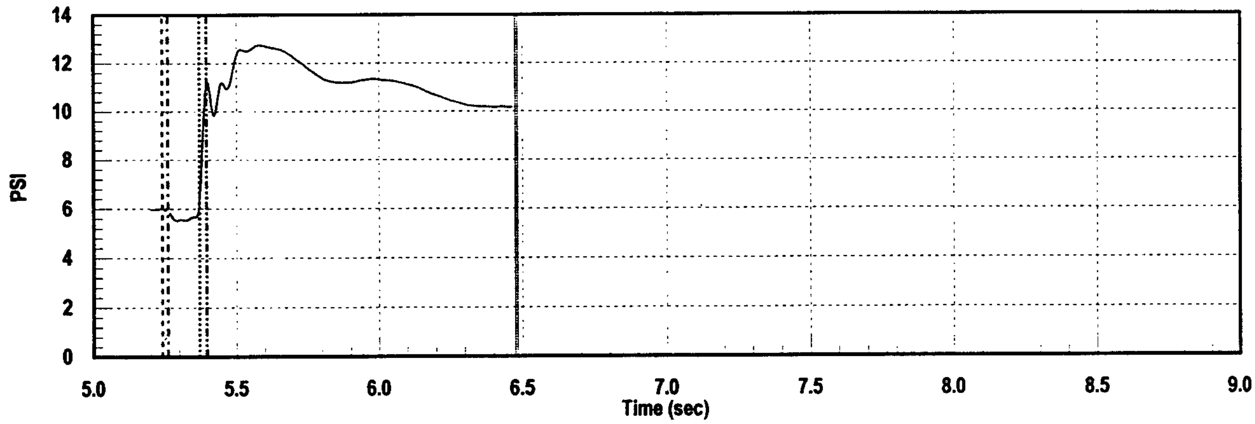
Lumbar Moment Z



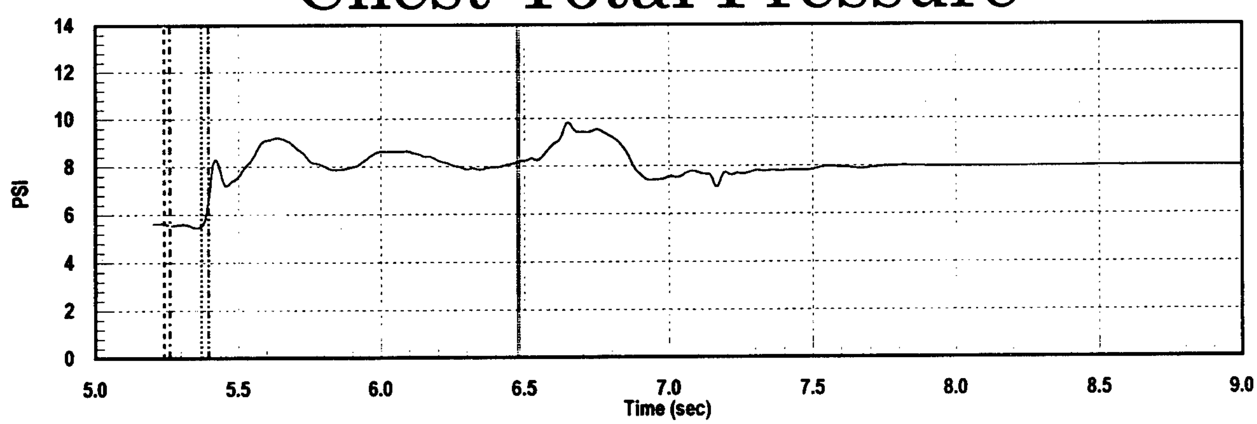
A-13

FL083301, 450 KEAS, 1,200 Ft

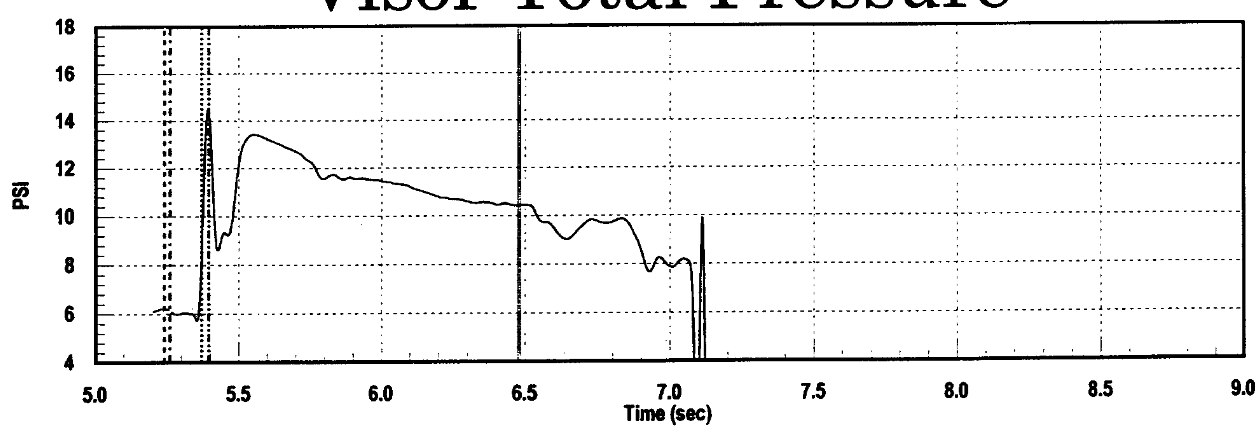
Windblast Deflector Total Pressure



Chest Total Pressure



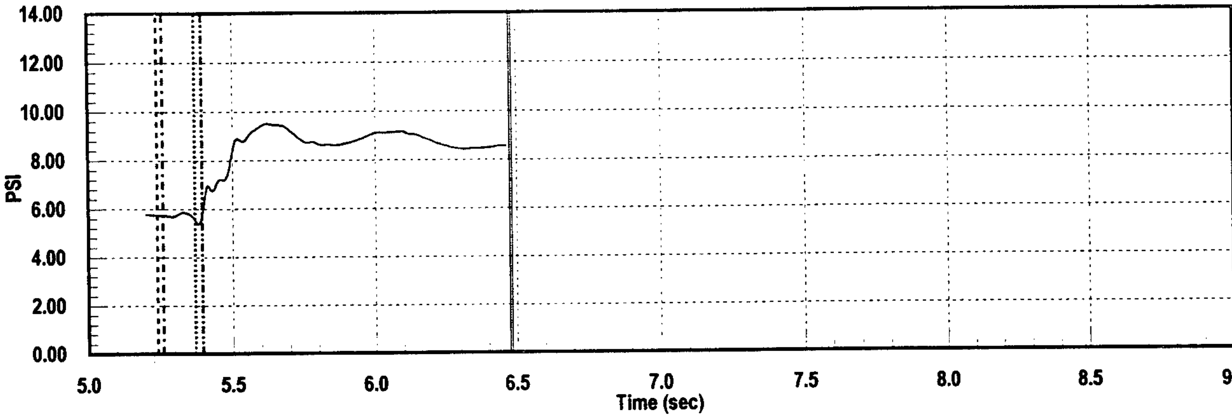
Visor Total Pressure



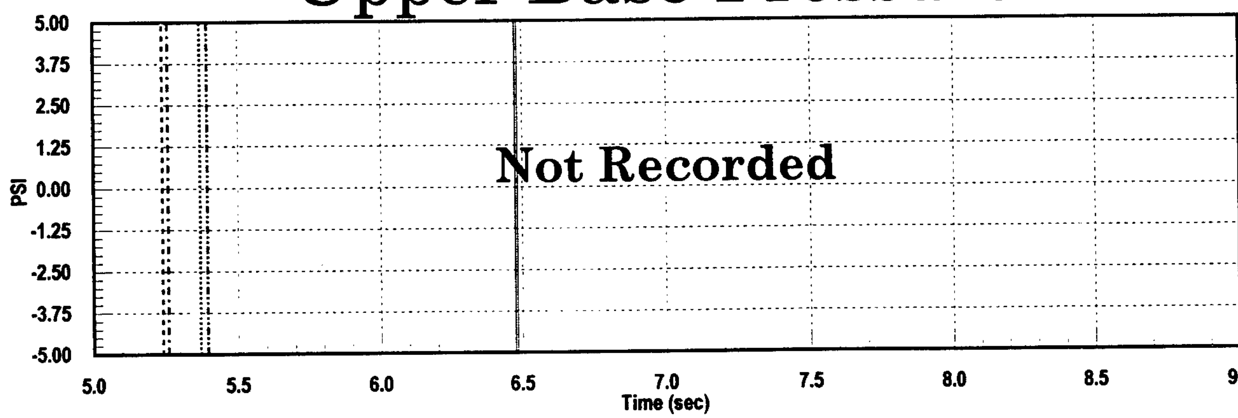
A-14

FL083301, 450 KEAS, 1,200 Ft

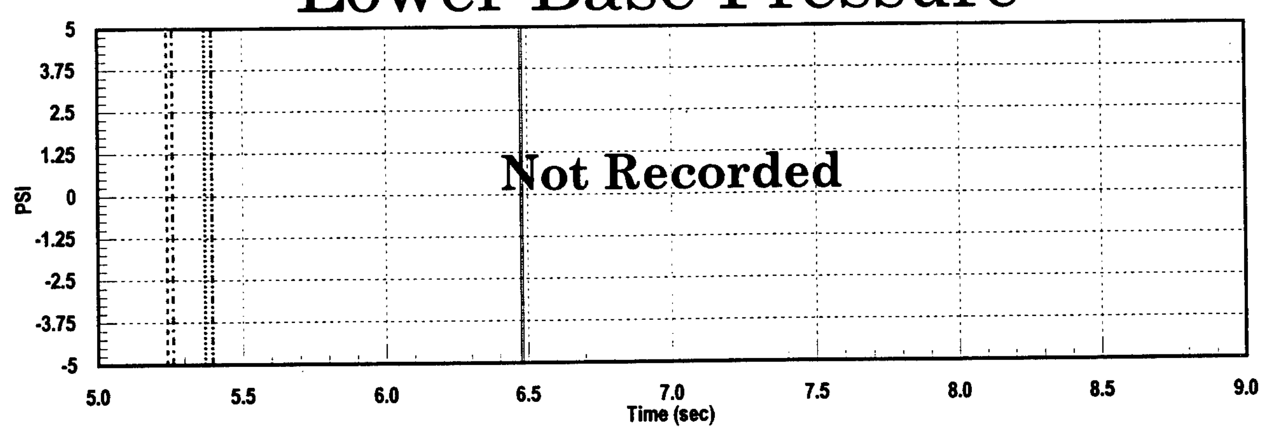
Windblast Deflector Static Pressure



Upper Base Pressure

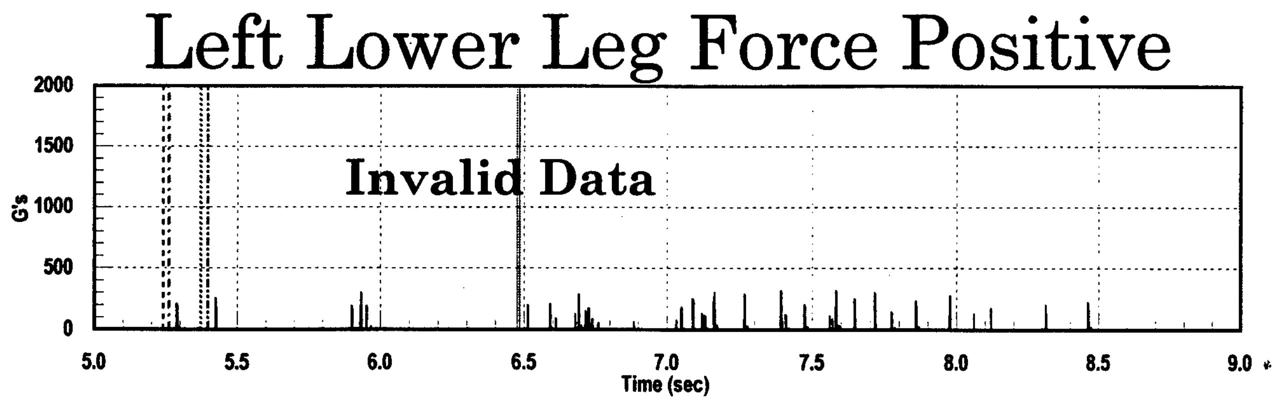


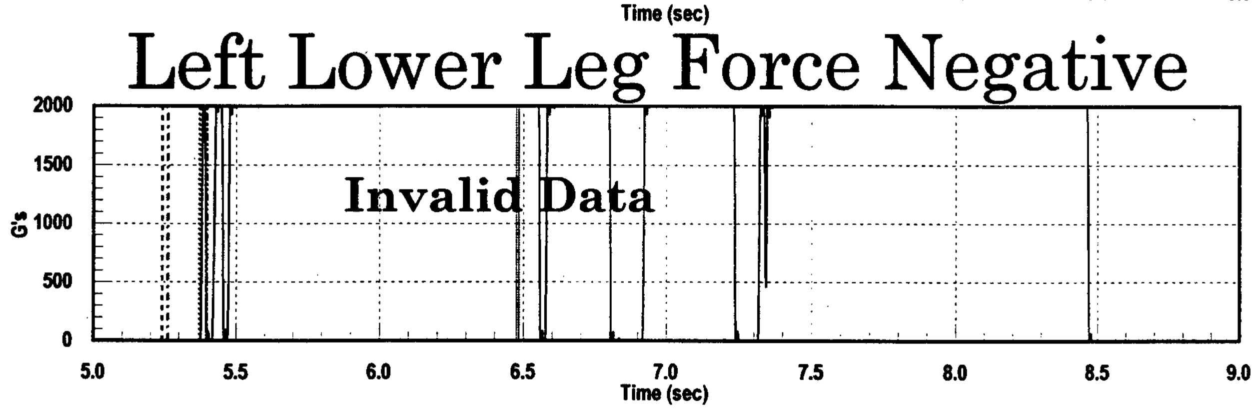
Lower Base Pressure

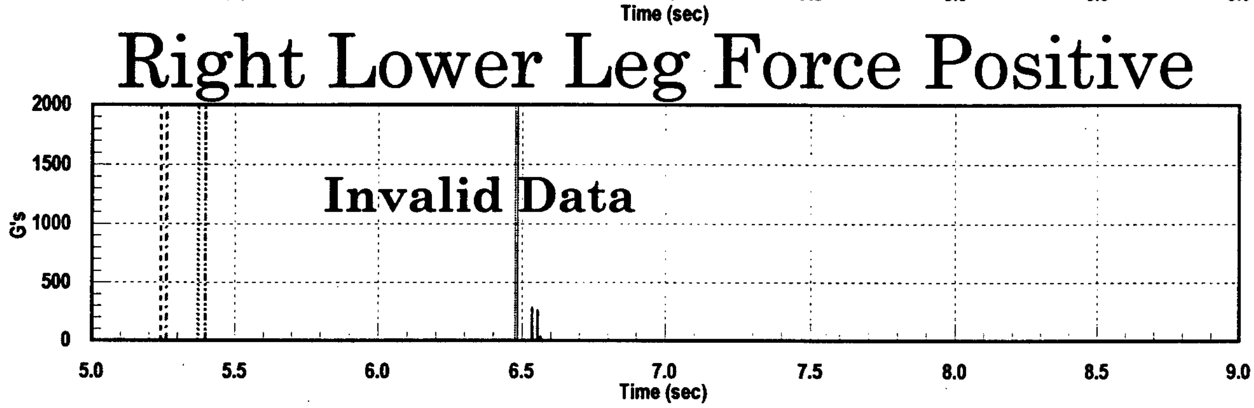


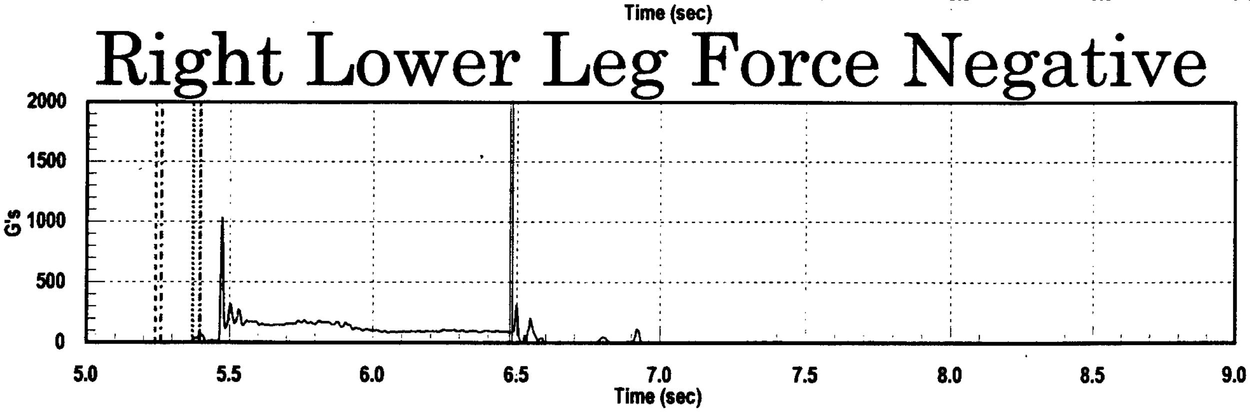
A-15

FL083301, 450 KEAS, 1,200 Ft





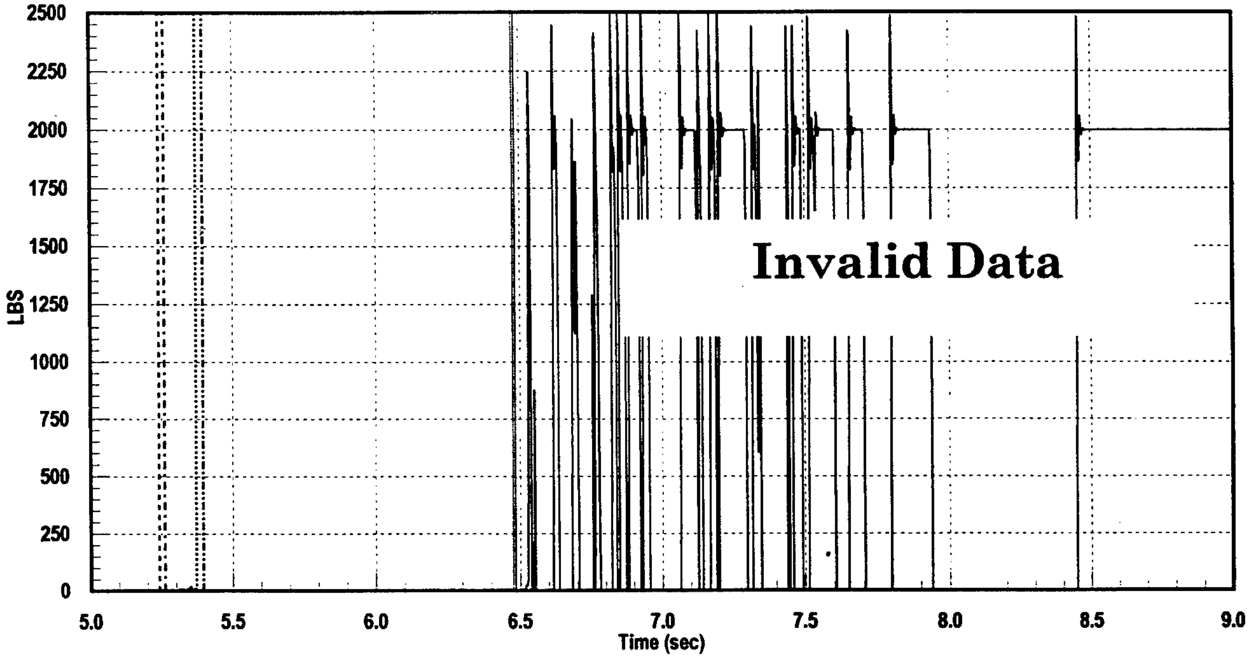




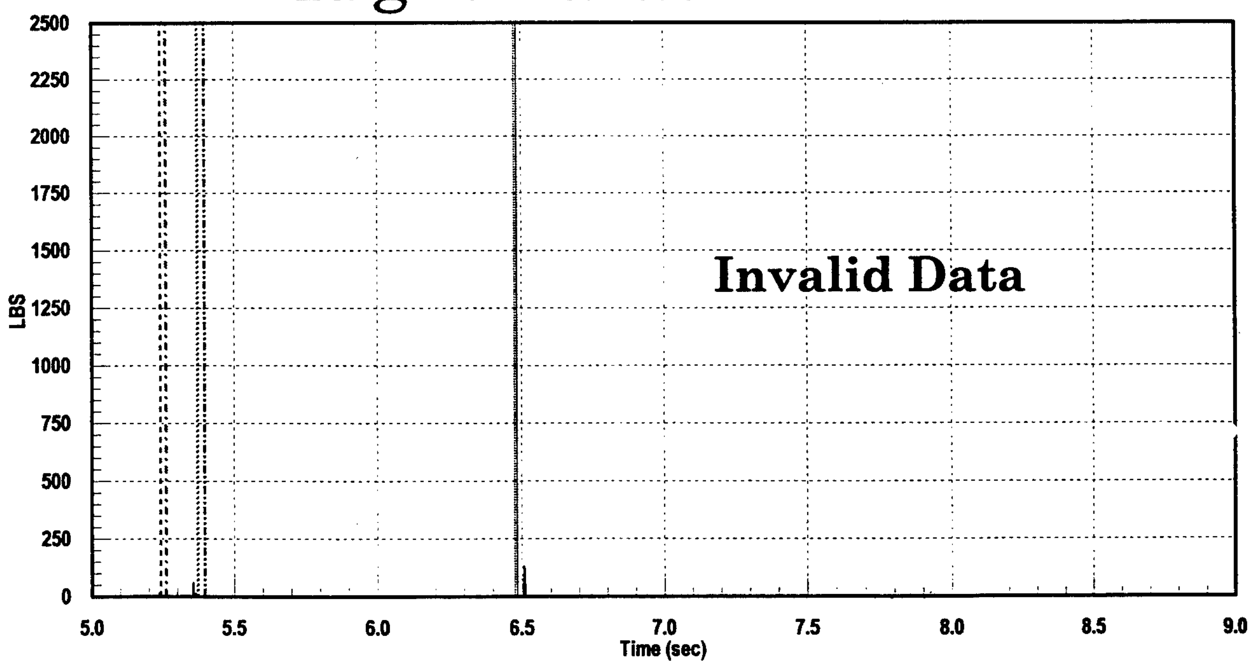
A-16

FL083301, 450 KEAS, 1,200 Ft

Left Parachute Riser



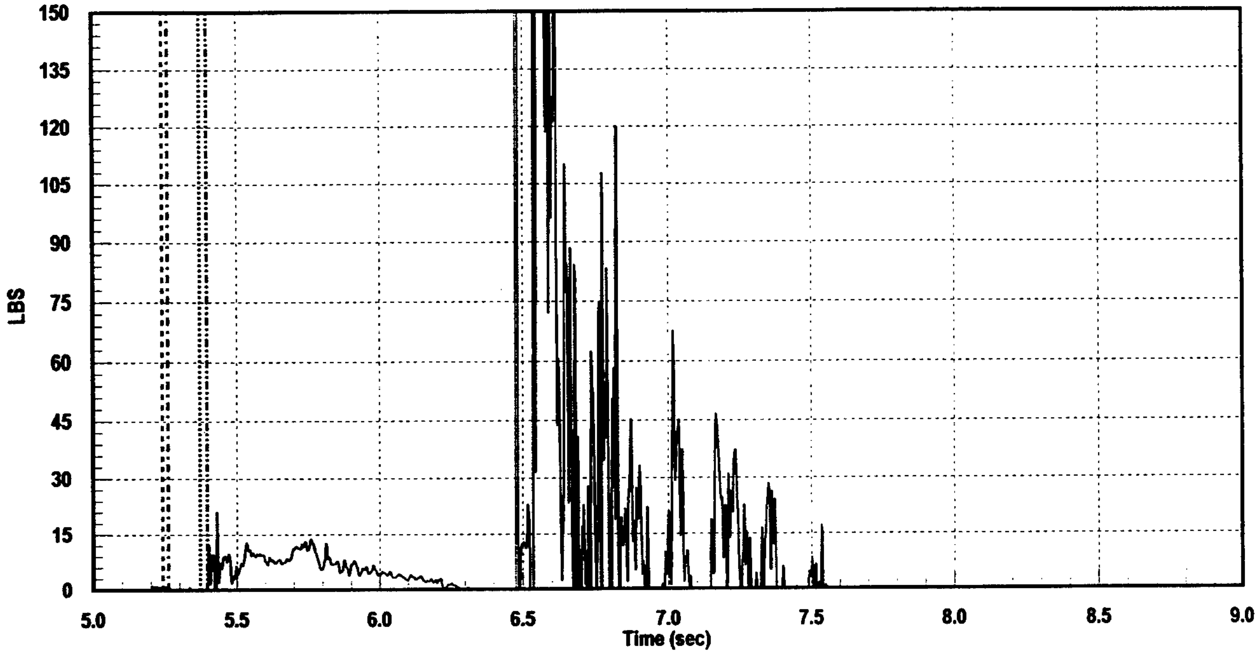
Right Parachute Riser



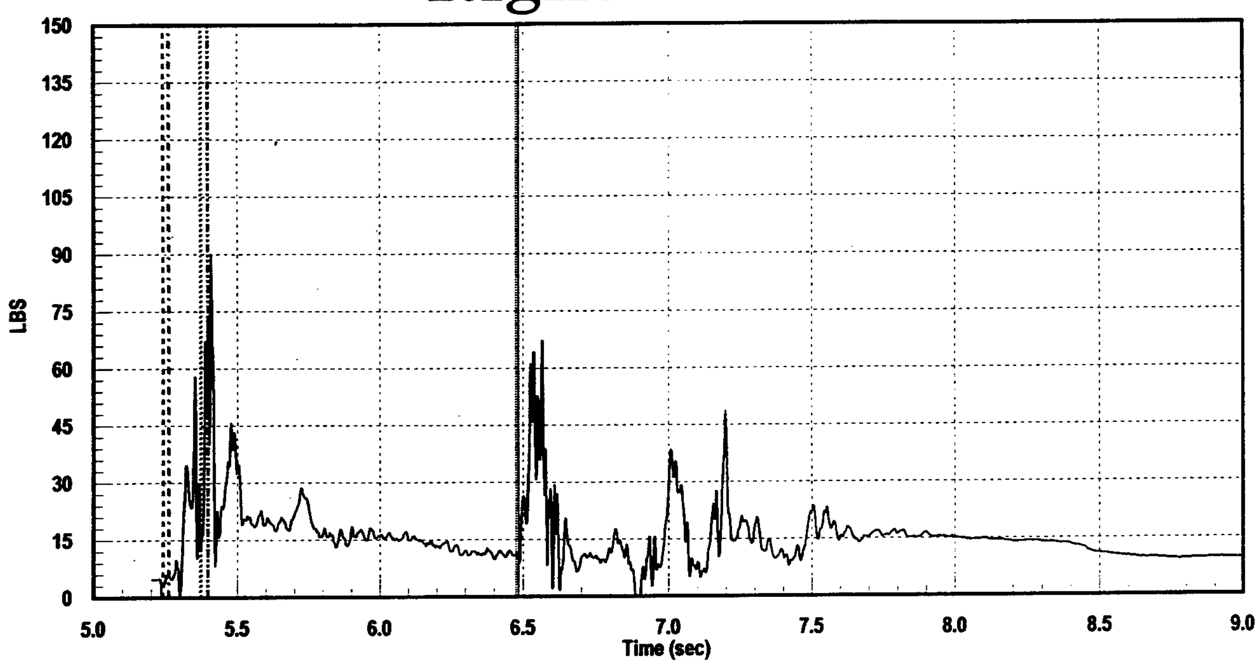
A-17

FL083301, 450 KEAS, 1,200 Ft

Left Arm Lift

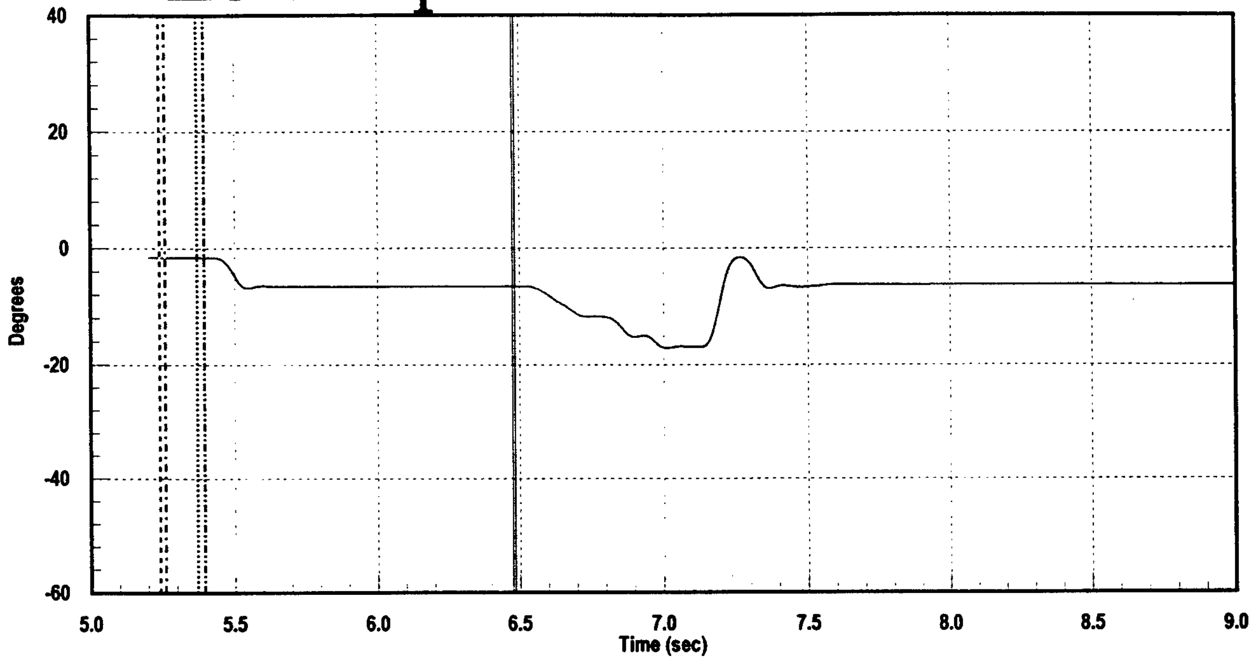


Right Arm Lift

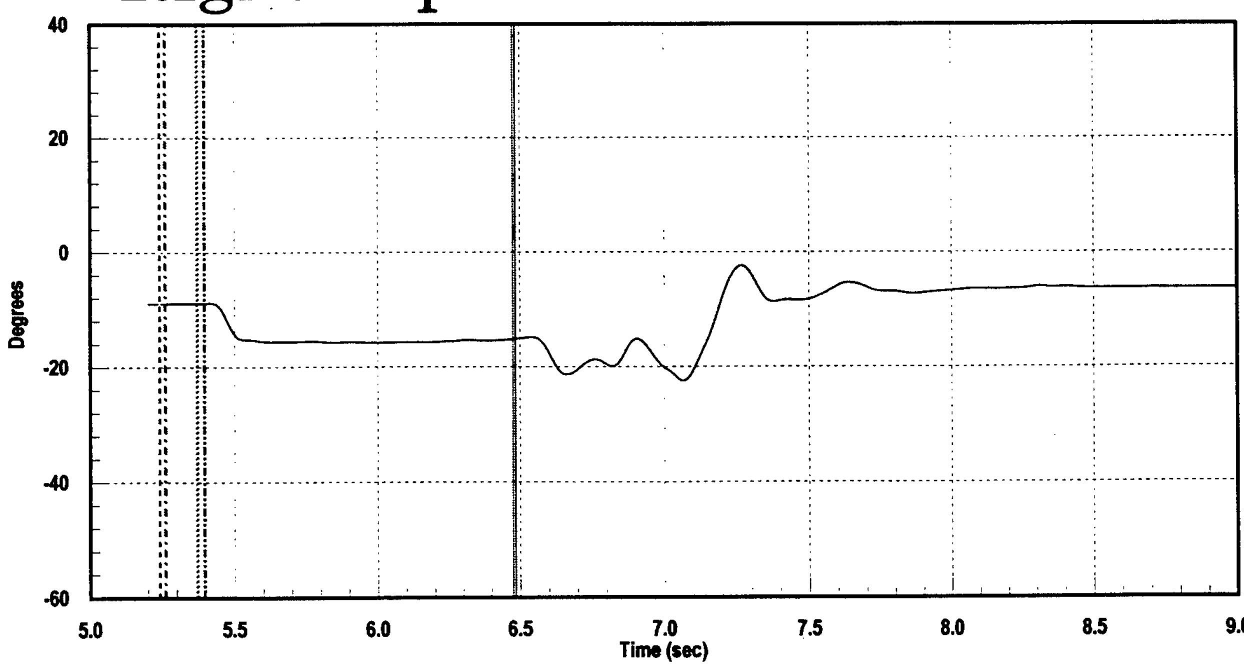


FL083301, 450 KEAS, 1,200 Ft

Left Hip Abduction/Adduction

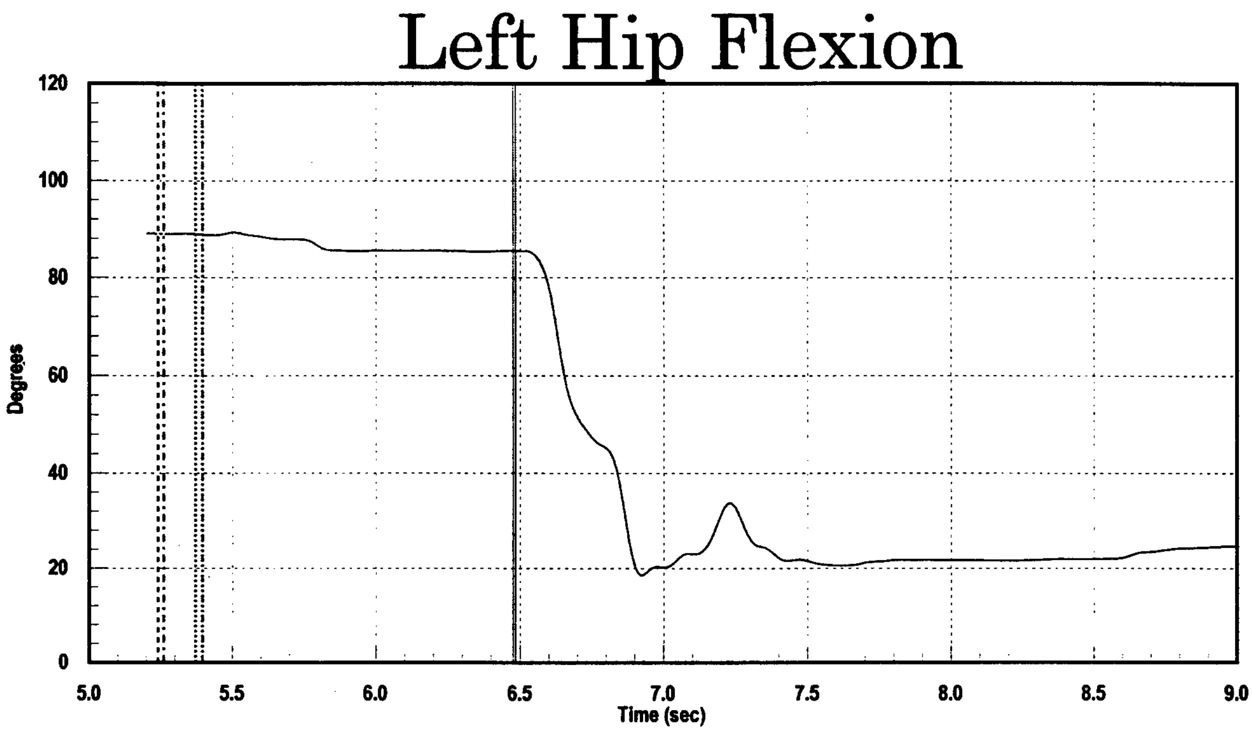


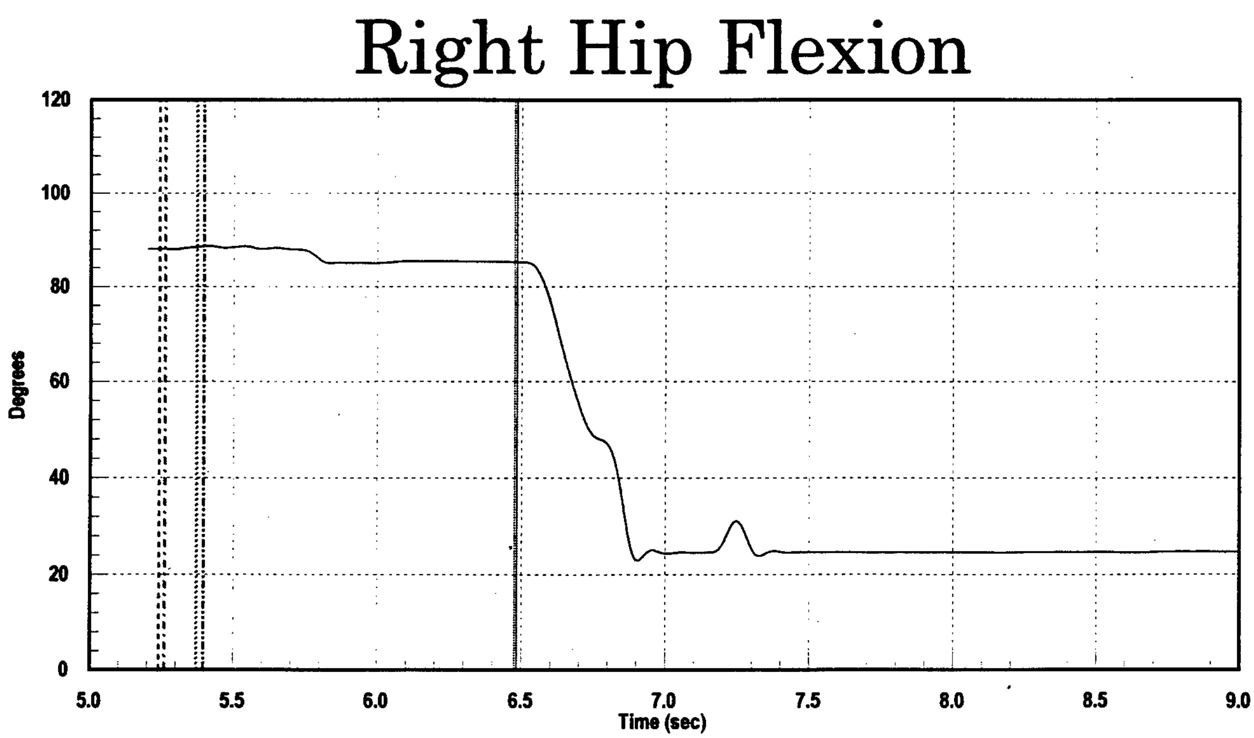
Right Hip Abduction/Adduction



A-19

FL083301, 450 KEAS, 1,200 Ft

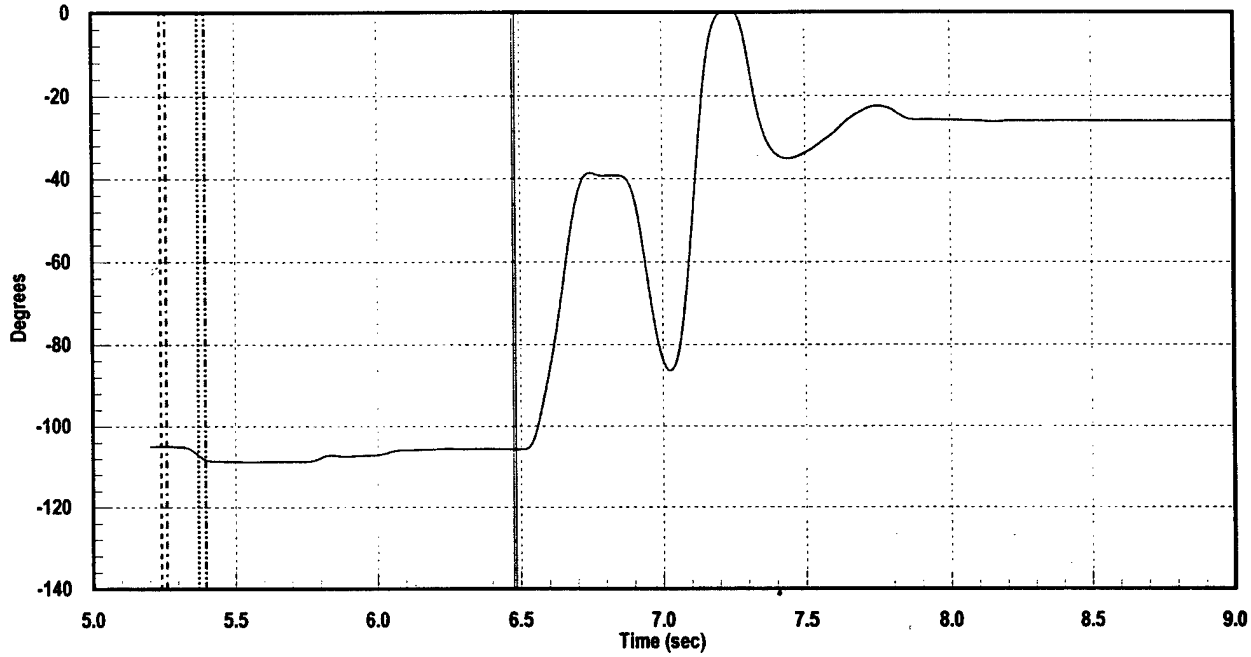




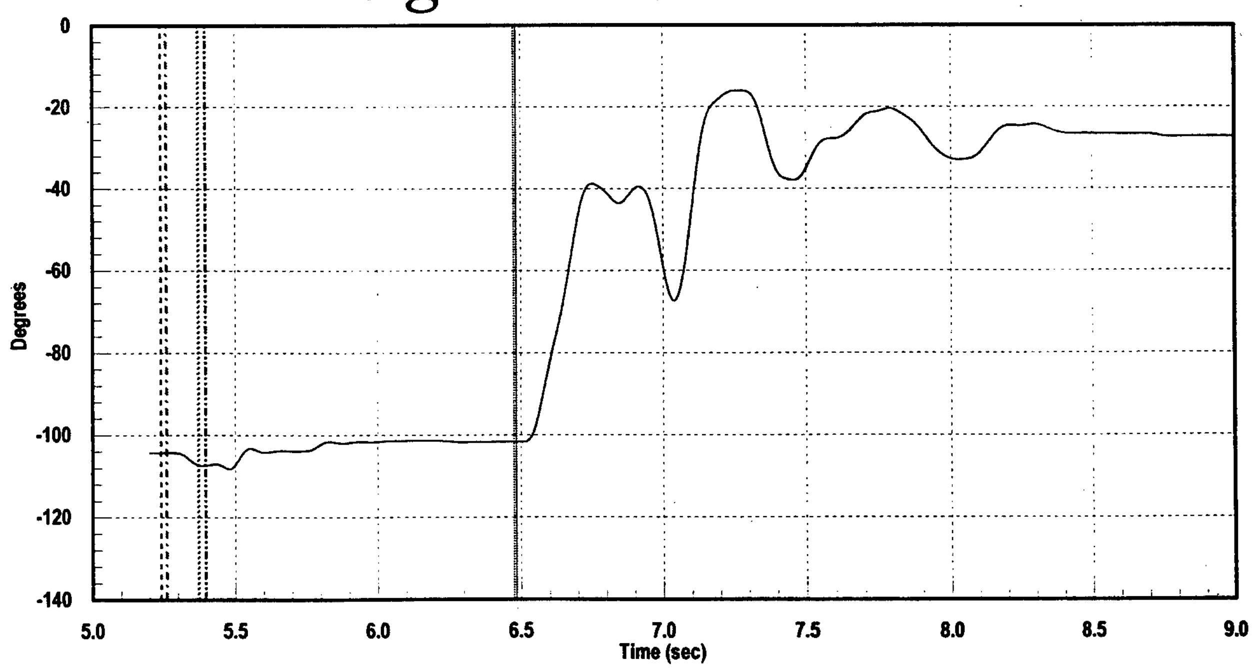
A-20

FL083301, 450 KEAS, 1,200 Ft

Left Knee Flexion



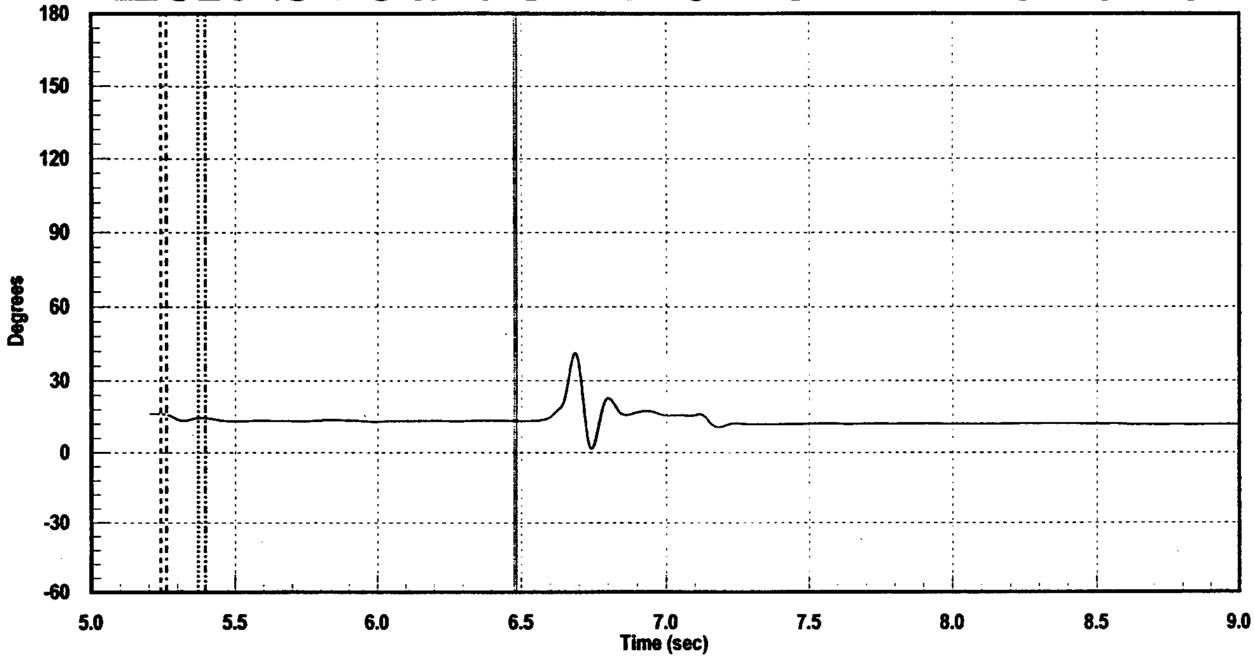
Right Knee Flexion



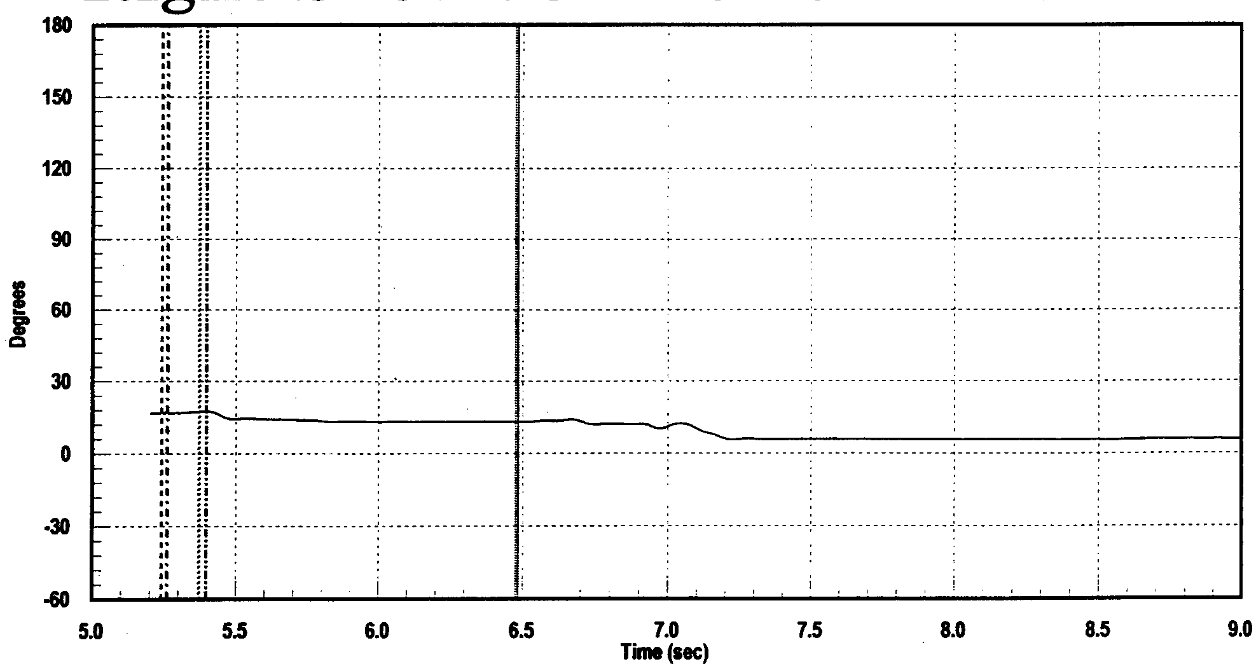
A-21

FL083301, 450 KEAS, 1,200 Ft

Left Shoulder Flexion/Extenstion



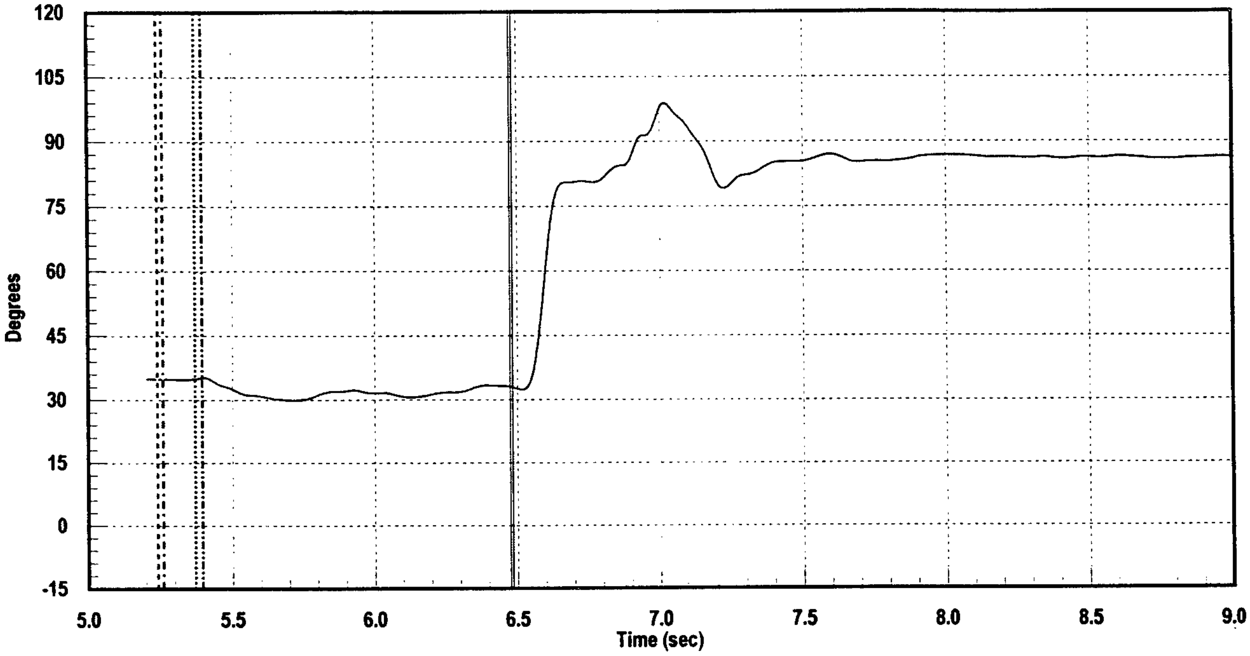
Right Shoulder Flexion/Extension



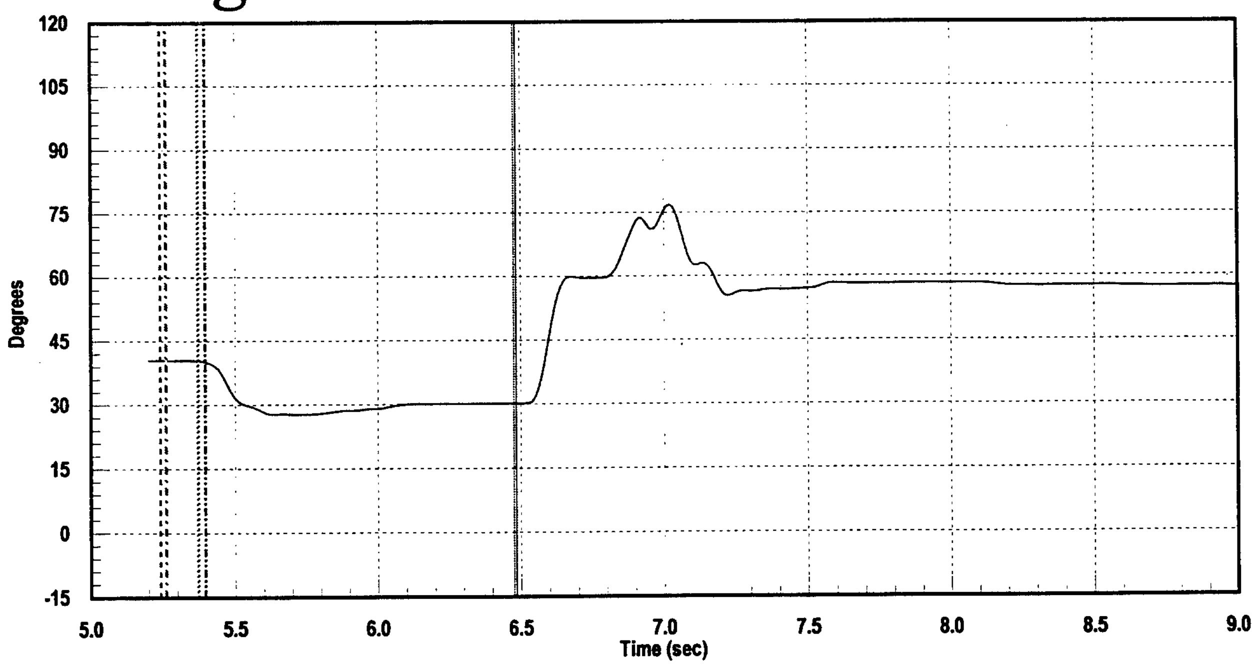
A-22

FL083301, 450 KEAS, 1,200 Ft

Left Shoulder Medial/Lateral



Right Shoulder Medial/Lateral



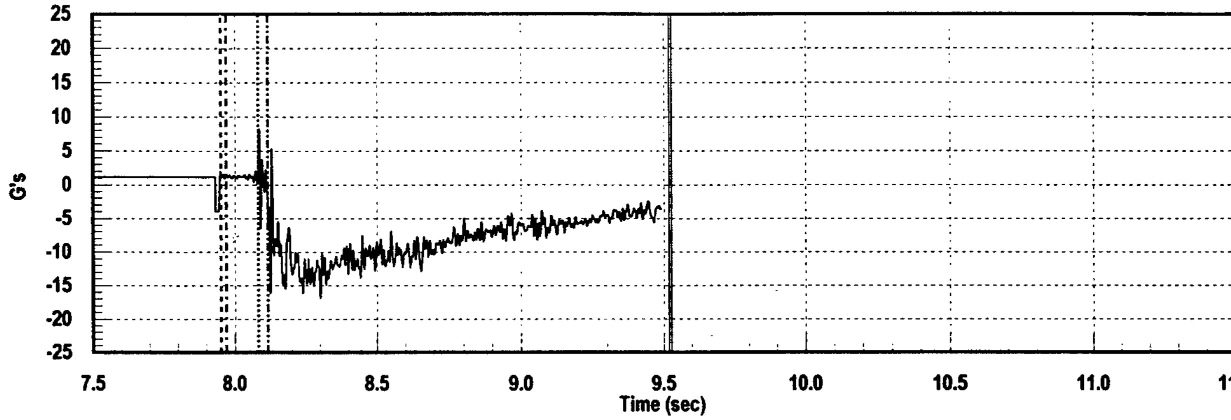
A-23

FL105001, 545 KEAS, 1,800 Feet
Processed Data

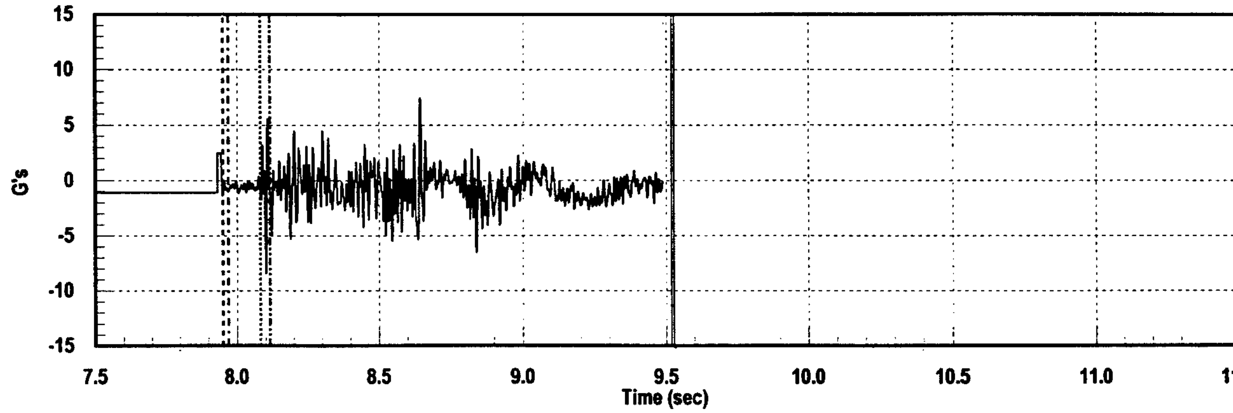
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL105001, 545 KEAS, 1,800 Feet

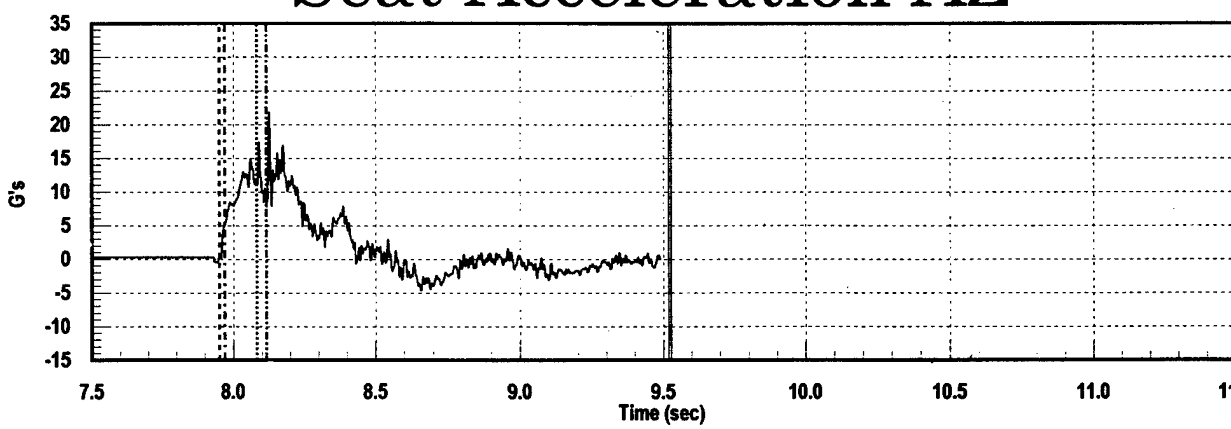
Seat Acceleration AX



Seat Acceleration AY



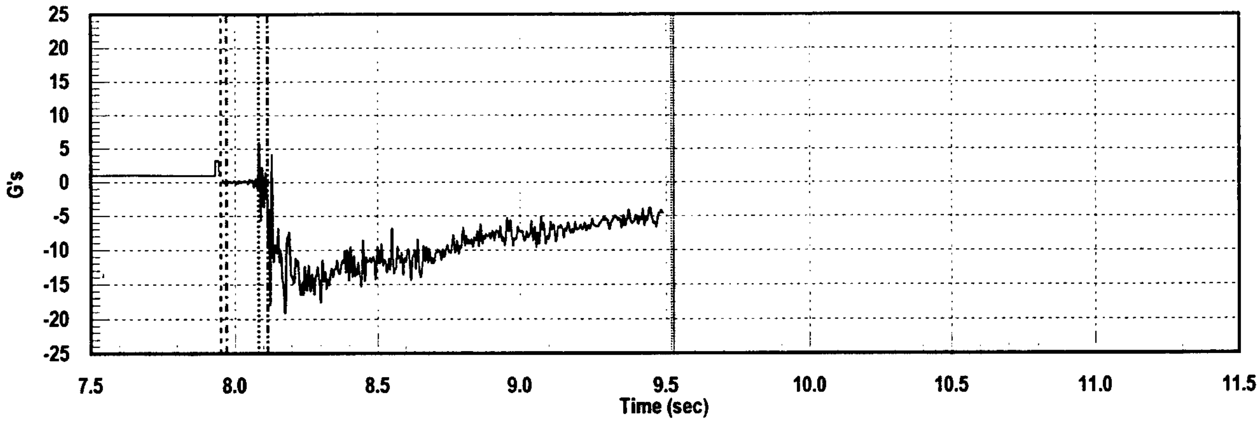
Seat Acceleration AZ



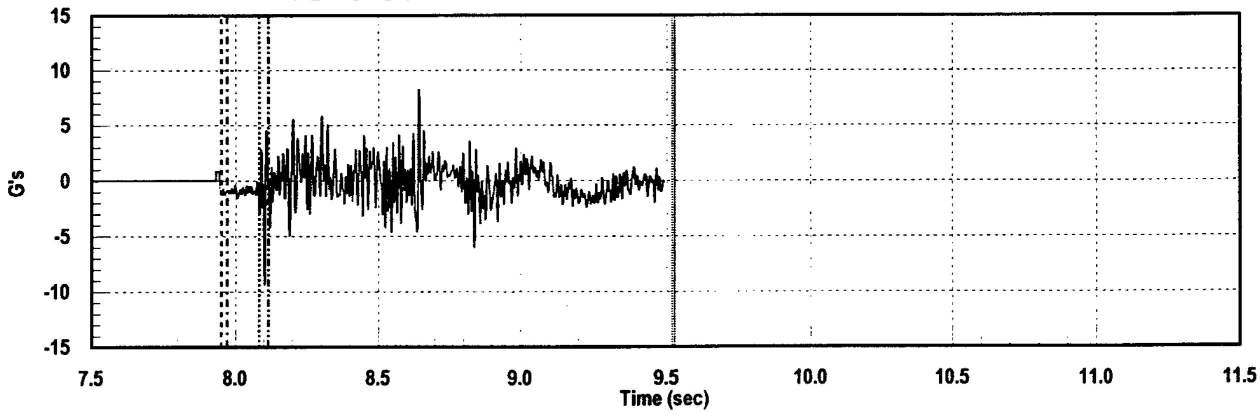
A-1

FL105001, 545 KEAS, 1,800 Feet

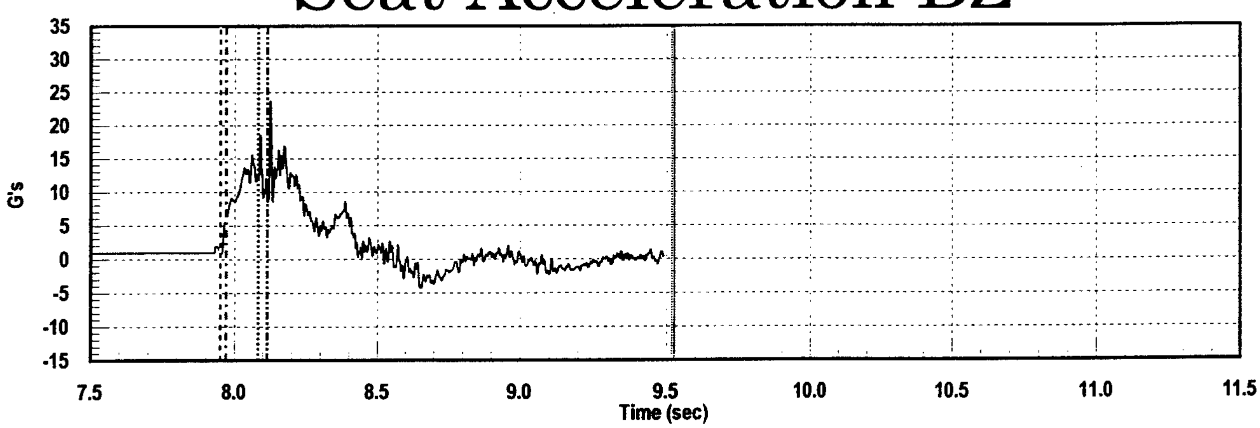
Seat Acceleration BX



Seat Acceleration BY



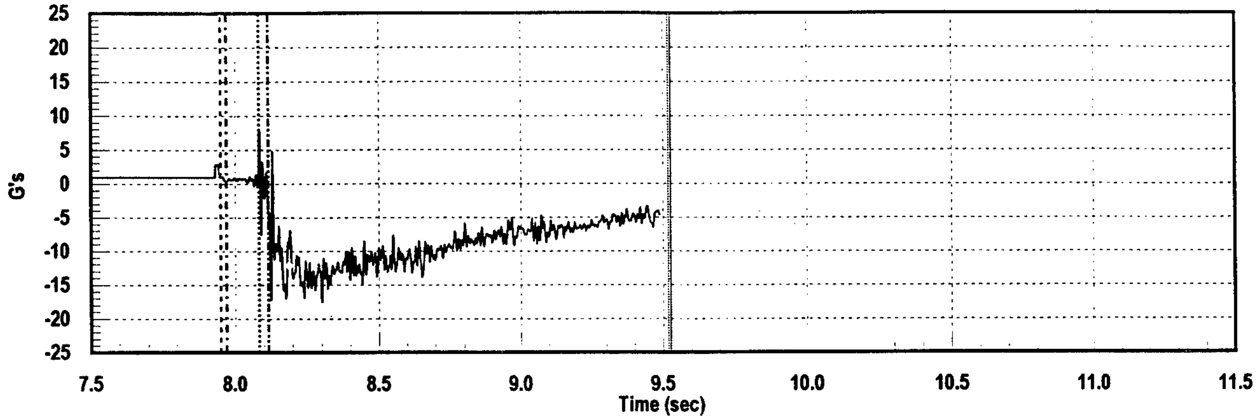
Seat Acceleration BZ



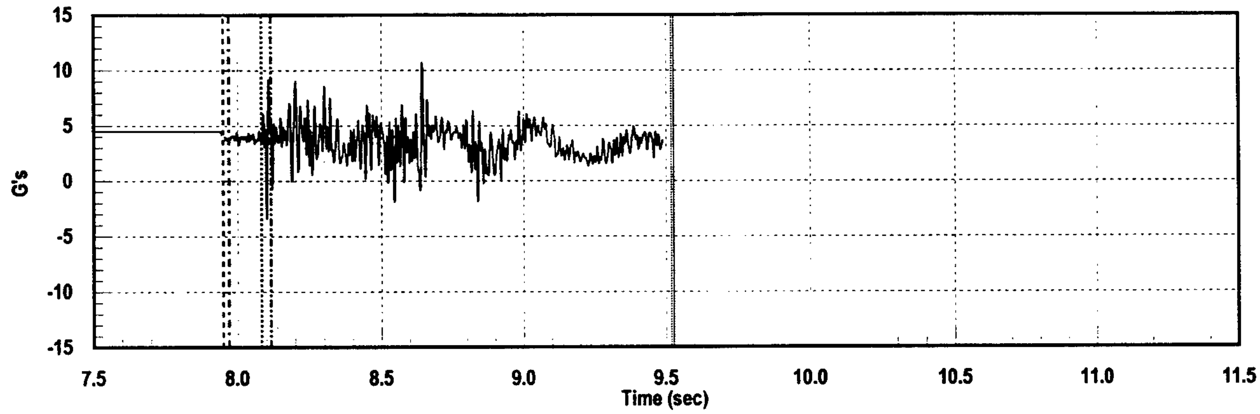
A-2

FL105001, 545 KEAS, 1,800 Feet

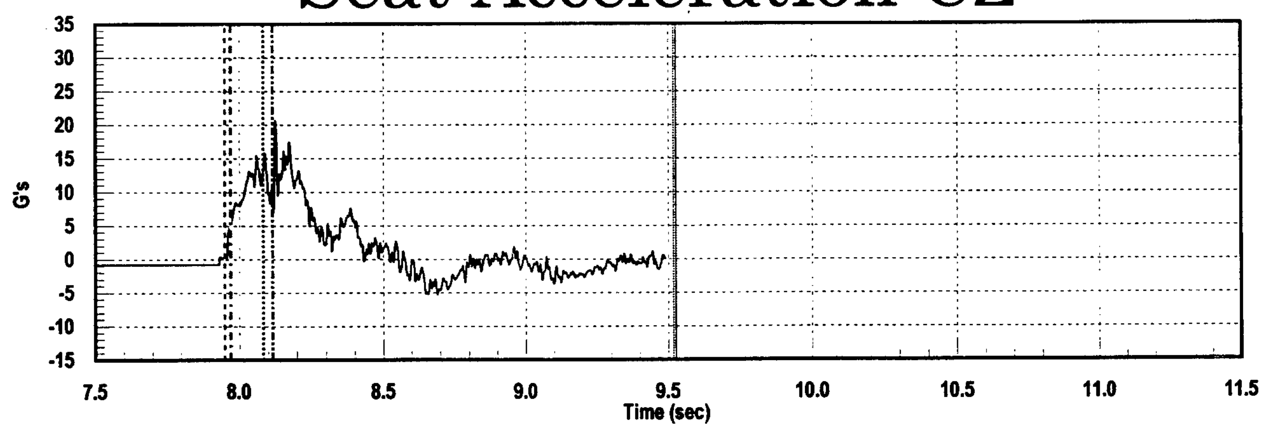
Seat Acceleration CX



Seat Acceleration CY



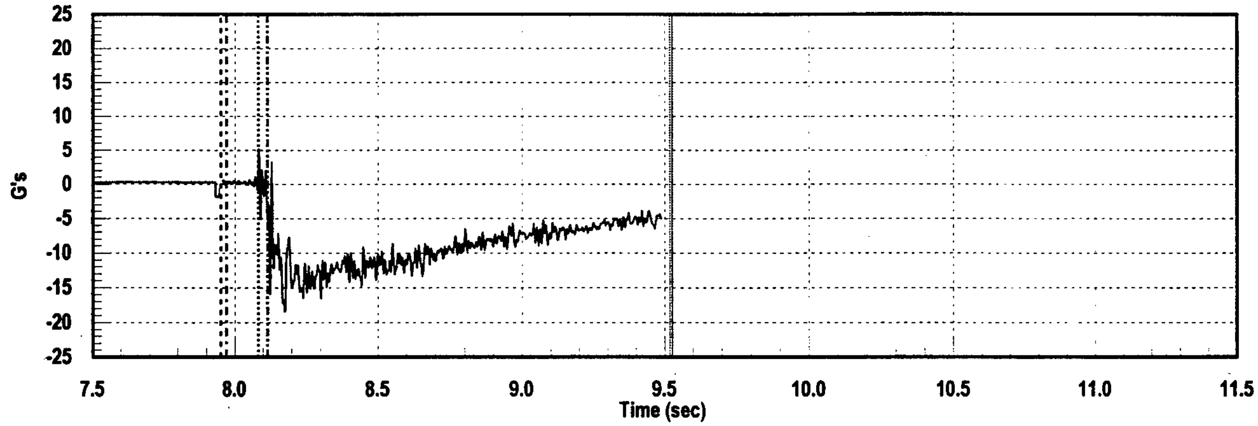
Seat Acceleration CZ



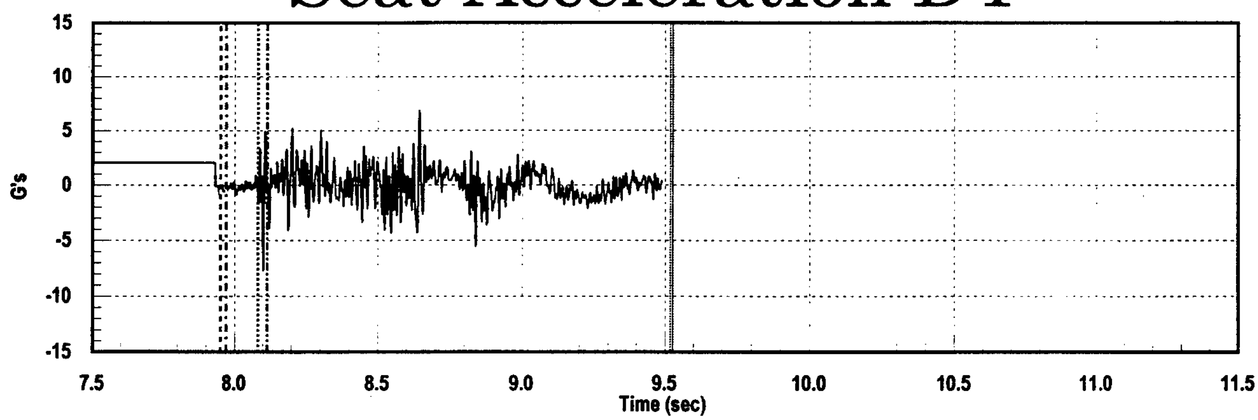
A-3

FL105001, 545 KEAS, 1,800 Feet

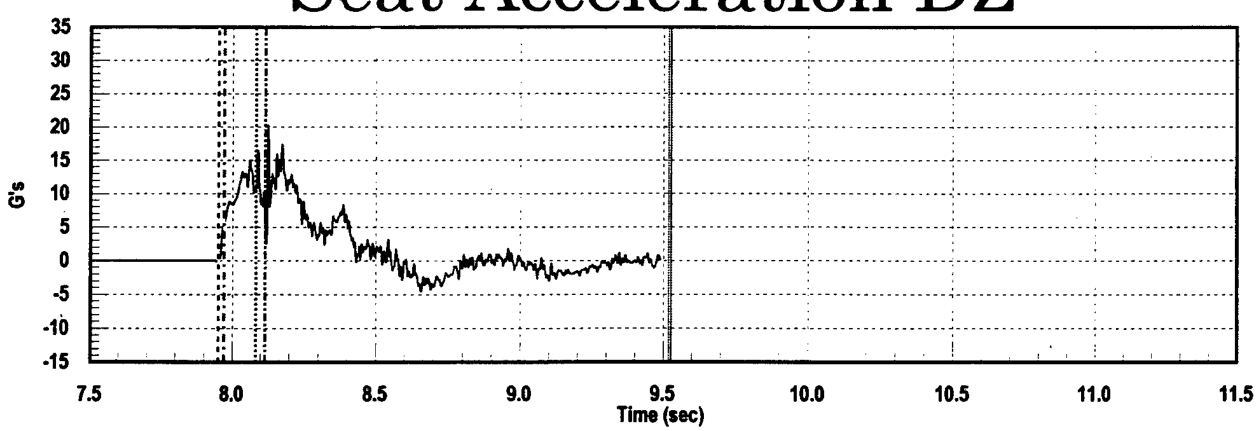
Seat Acceleration DX



Seat Acceleration DY



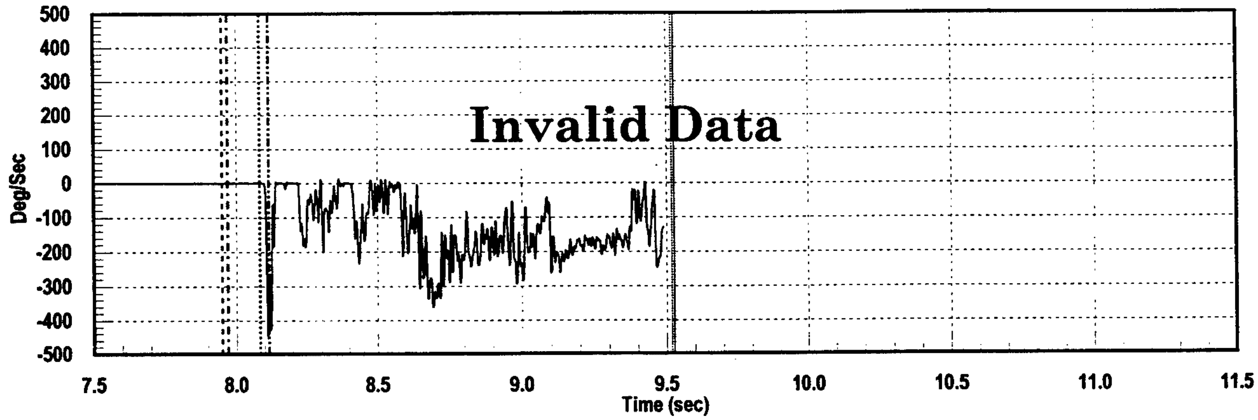
Seat Acceleration DZ



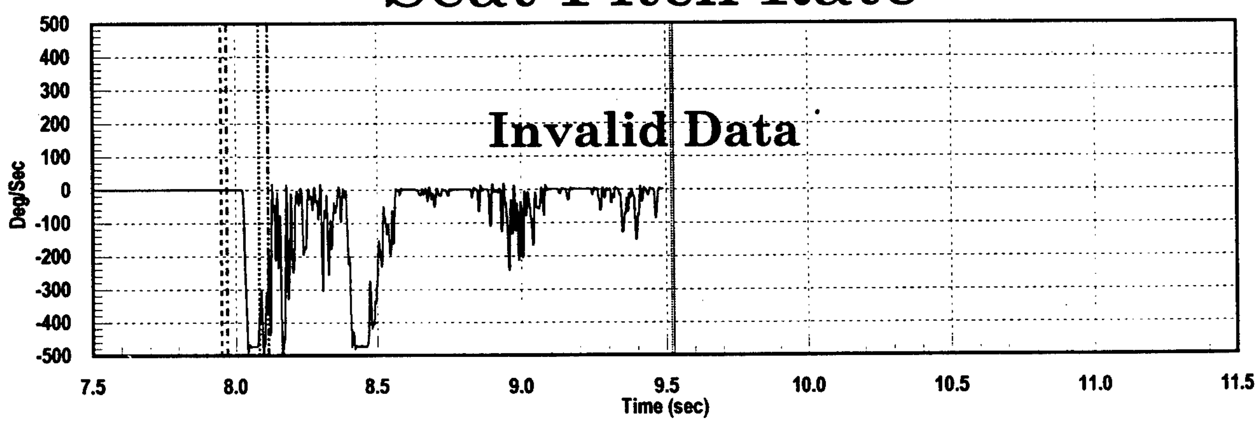
A-4

FL105001, 545 KEAS, 1,800 Feet

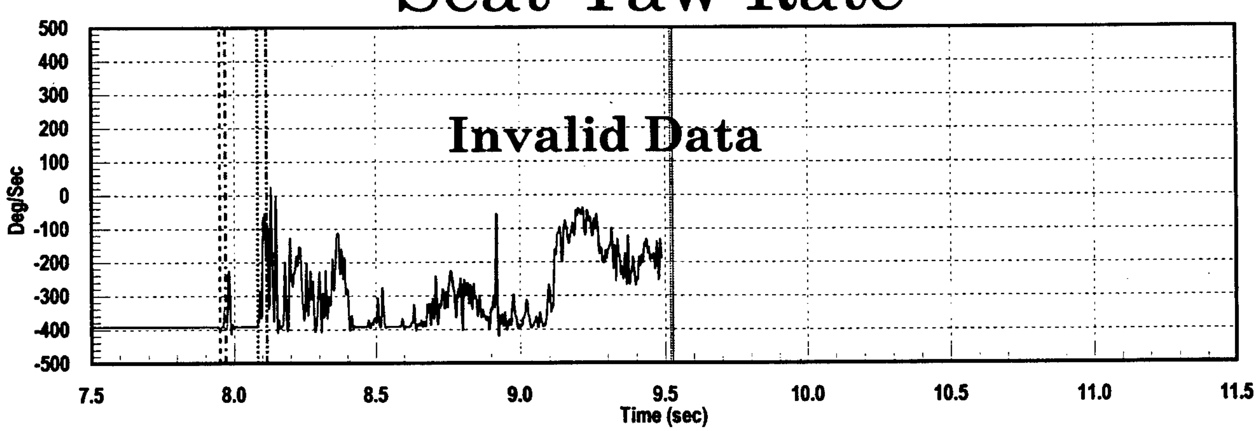
Seat Roll Rate



Seat Pitch Rate



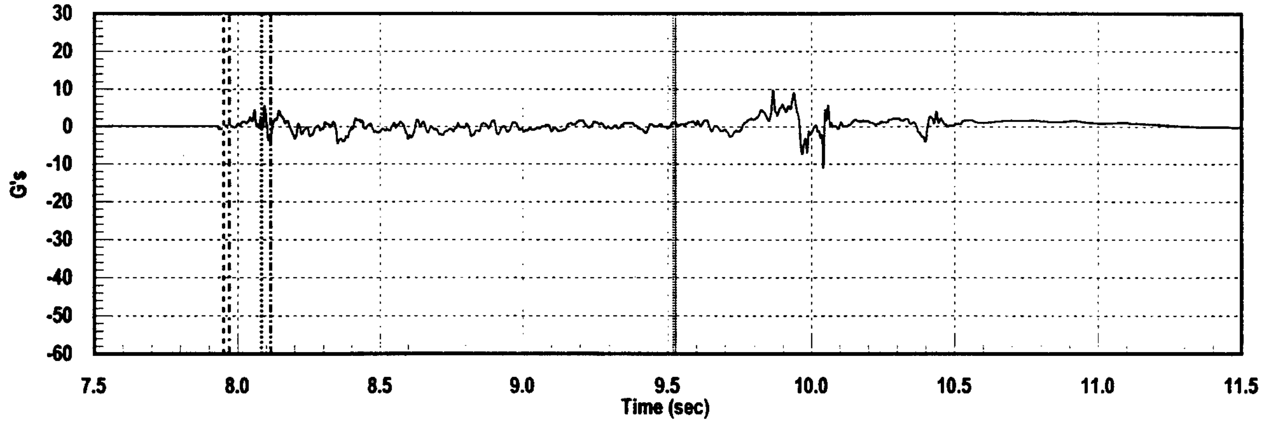
Seat Yaw Rate



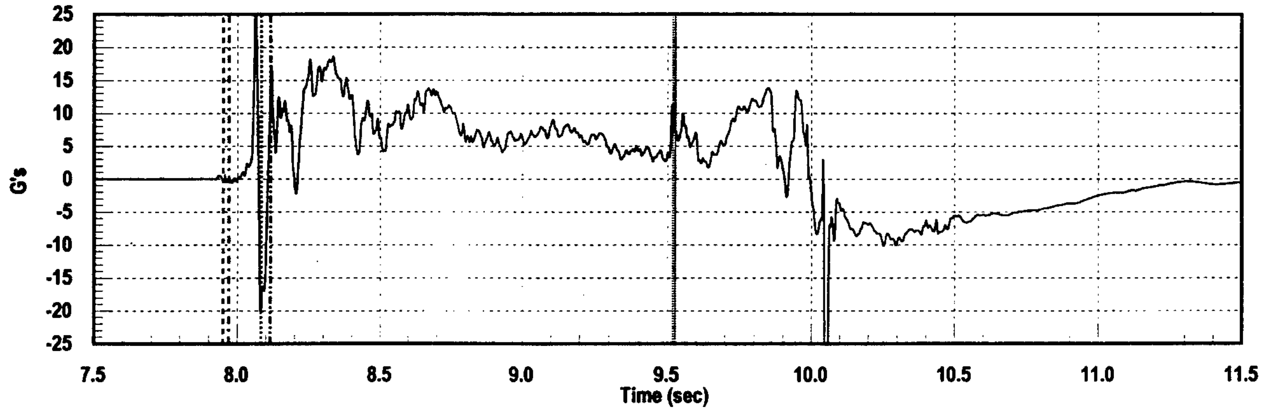
A-5

FL105001, 545 KEAS, 1,800 Feet

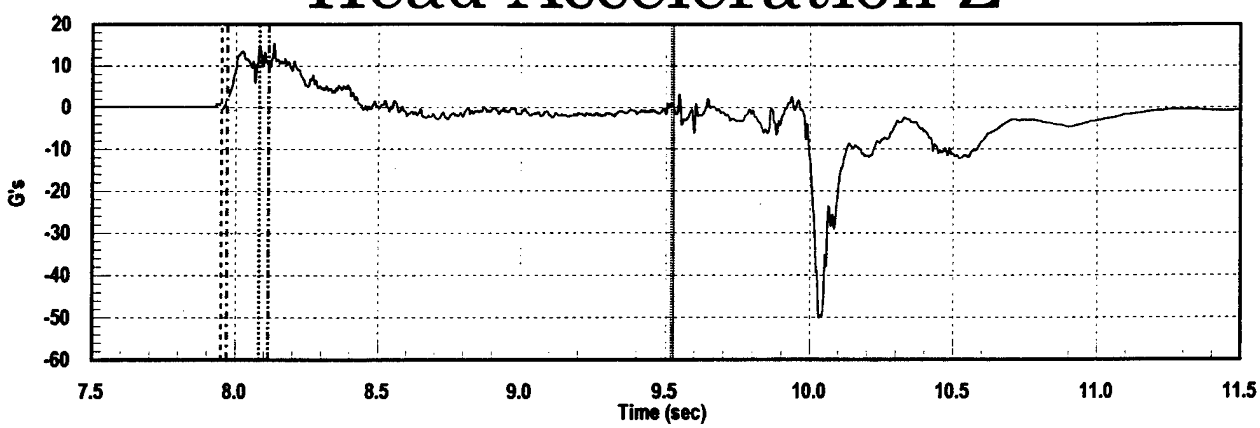
Head Acceleration X



Head Acceleration Y



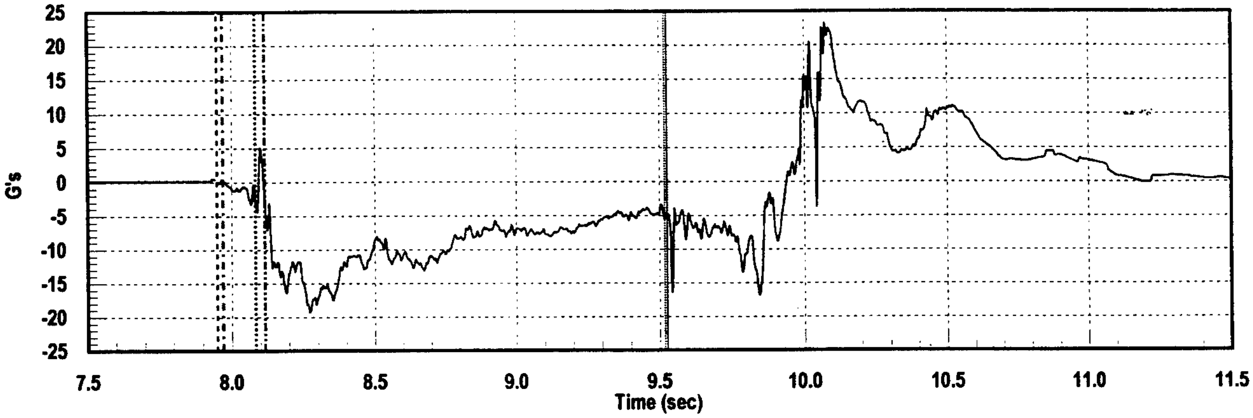
Head Acceleration Z



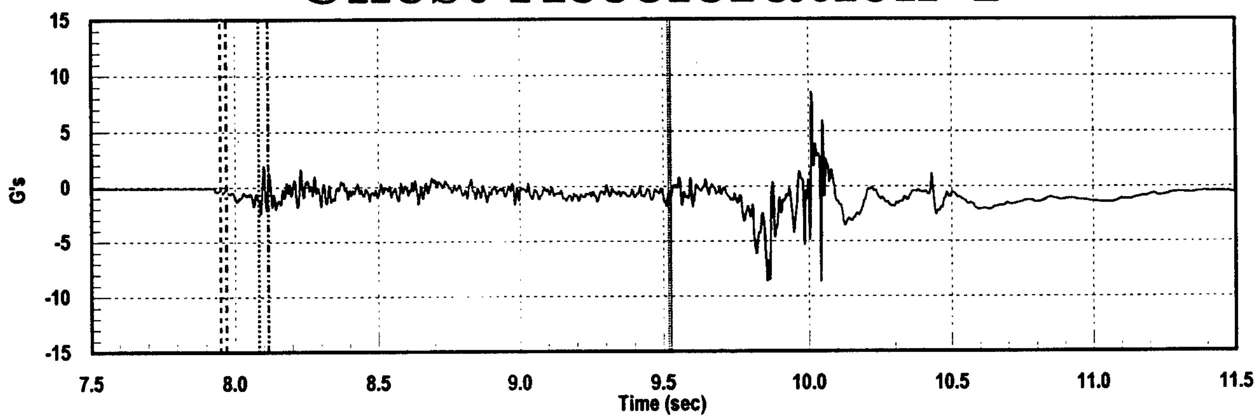
A-6

FL105001, 545 KEAS, 1,800 Feet

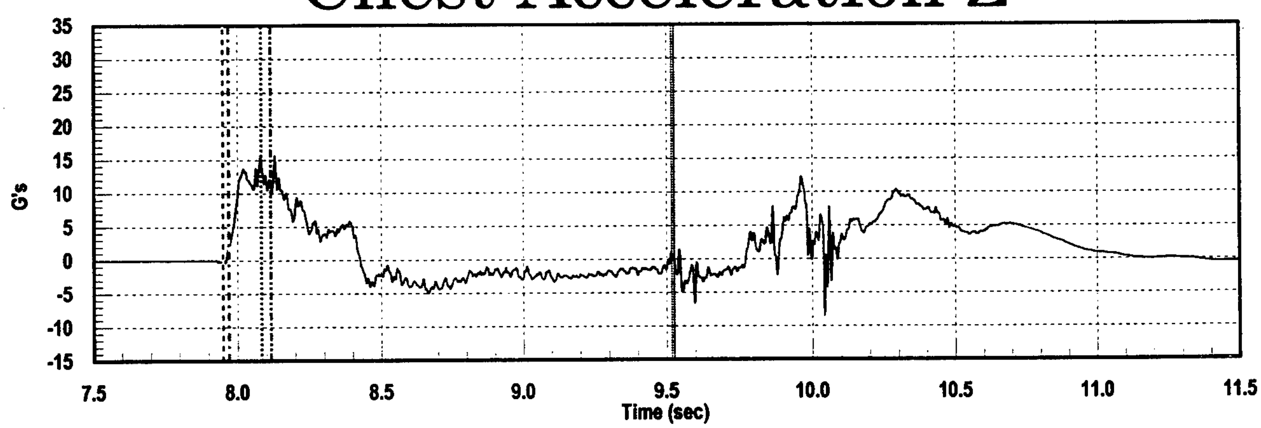
Chest Acceleration X



Chest Acceleration Y



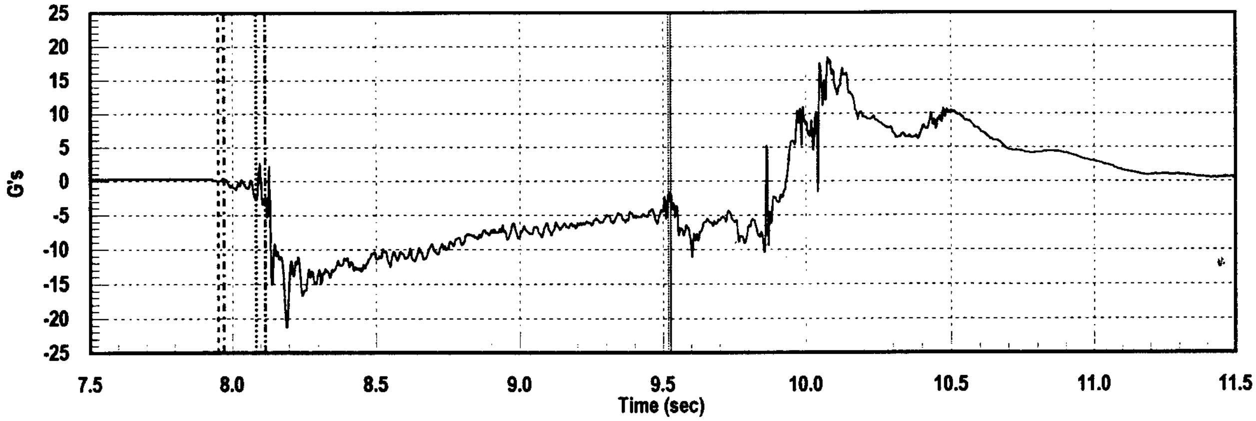
Chest Acceleration Z



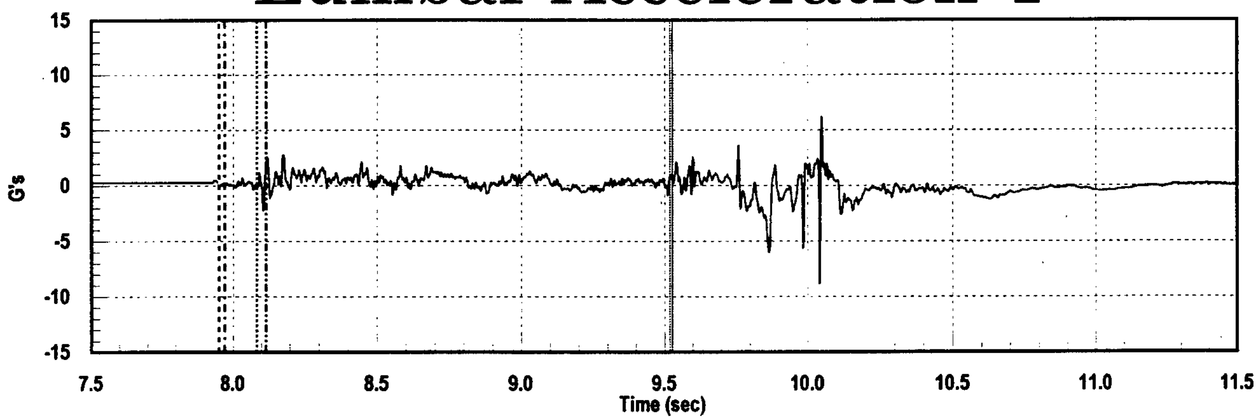
A-7

FL105001, 545 KEAS, 1,800 Feet

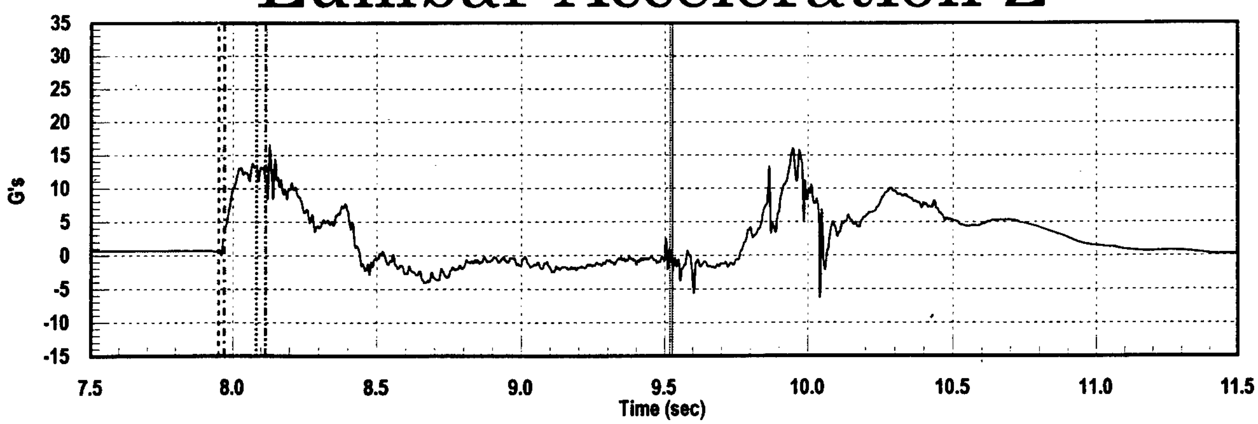
Lumbar Acceleration X



Lumbar Acceleration Y



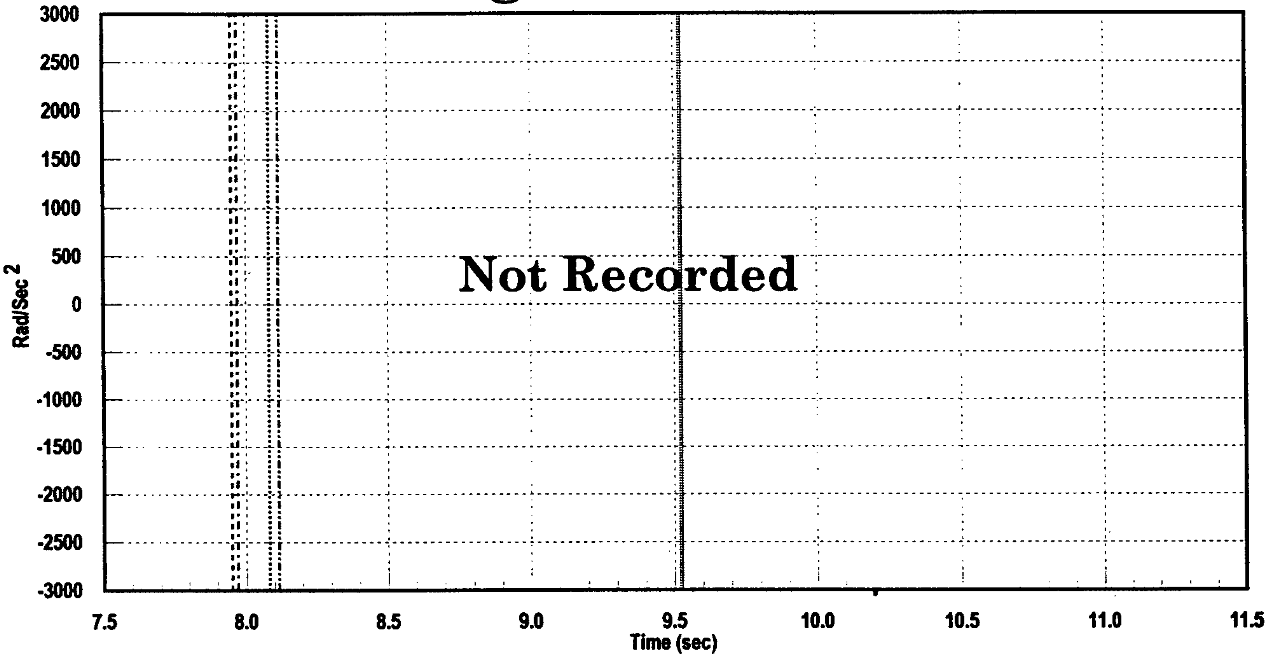
Lumbar Acceleration Z



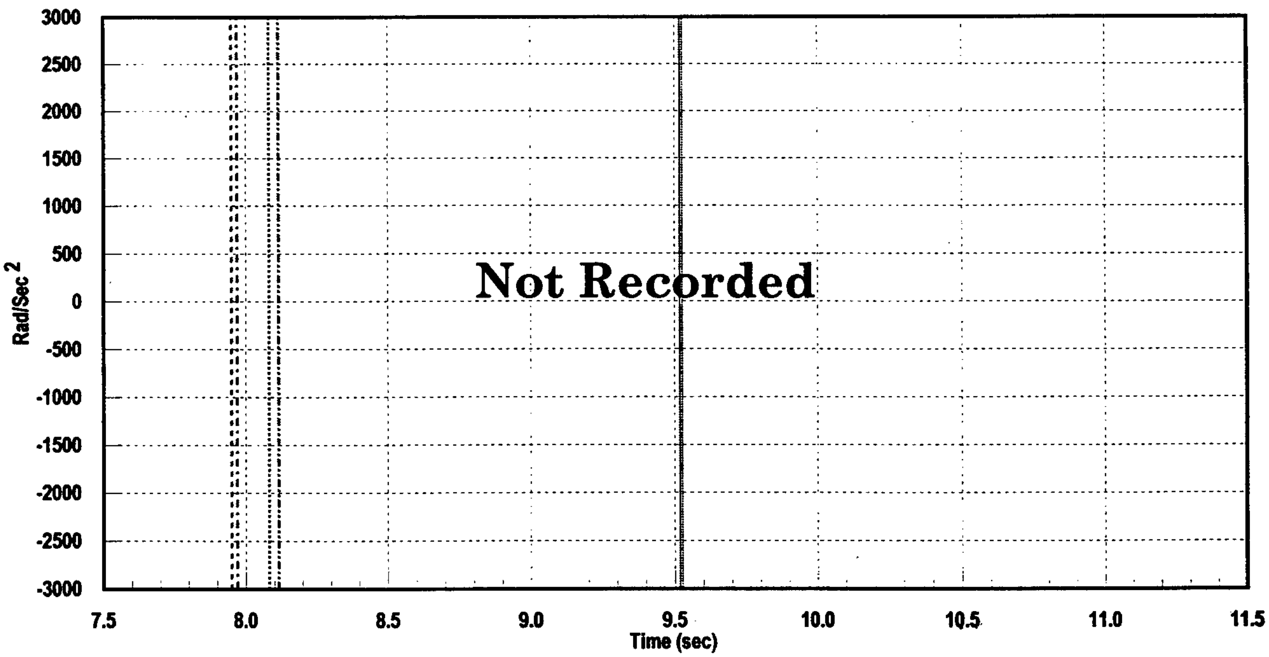
A-8

FL105001, 545 KEAS, 1,800 Feet

Head Angular Acceleration Y



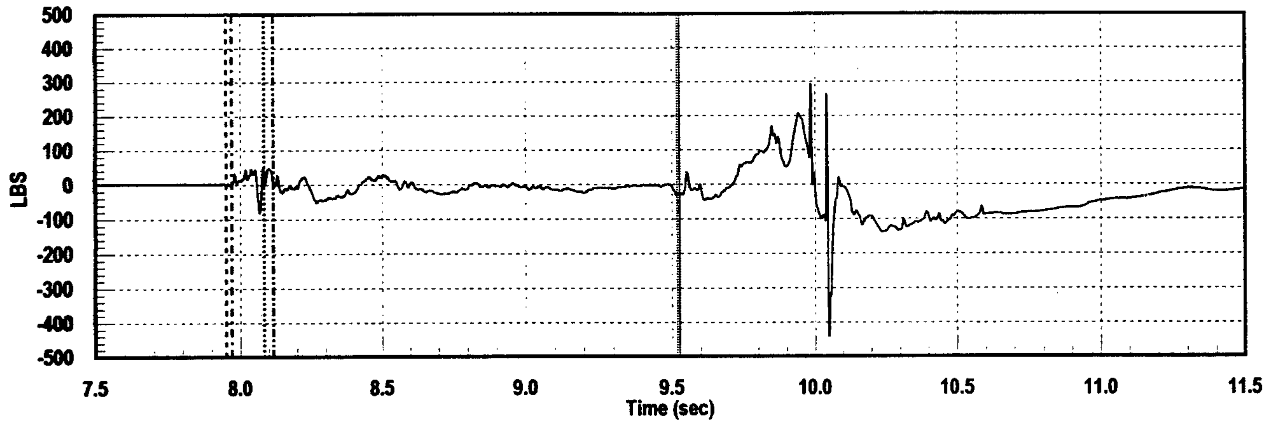
Chest Angular Acceleration Y



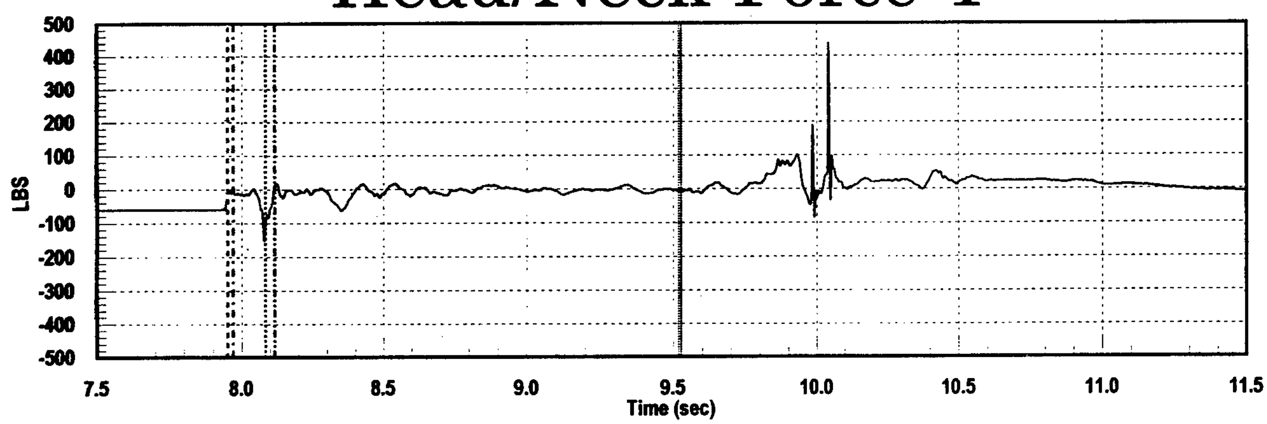
A-9

FL105001, 545 KEAS, 1,800 Feet

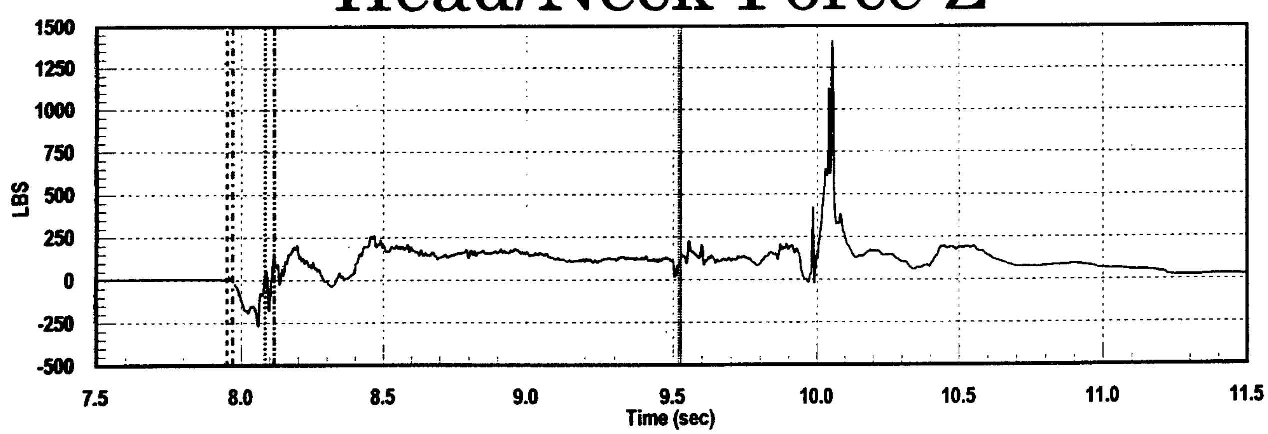
Head/Neck Force X



Head/Neck Force Y

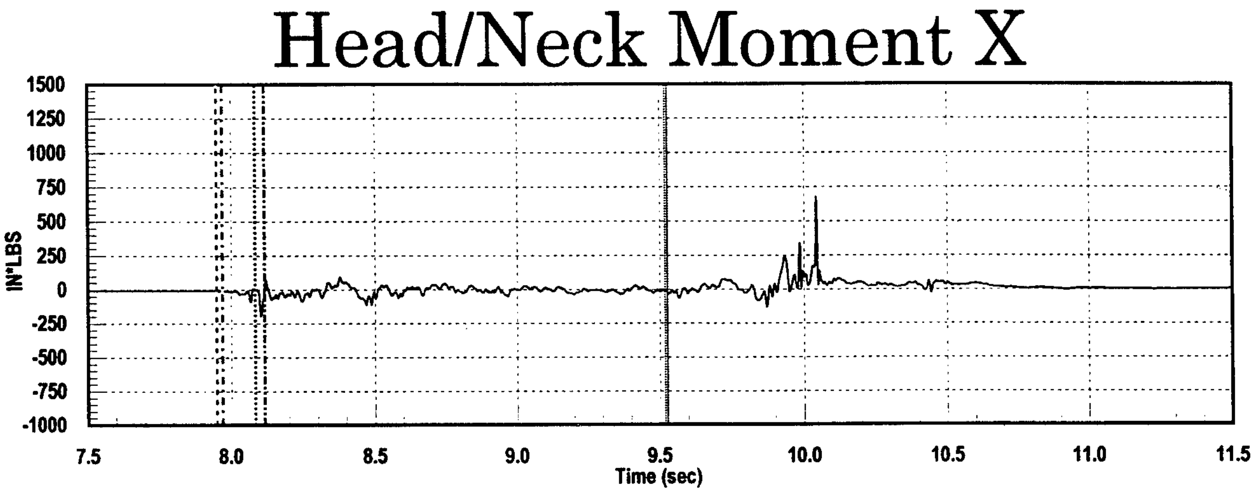


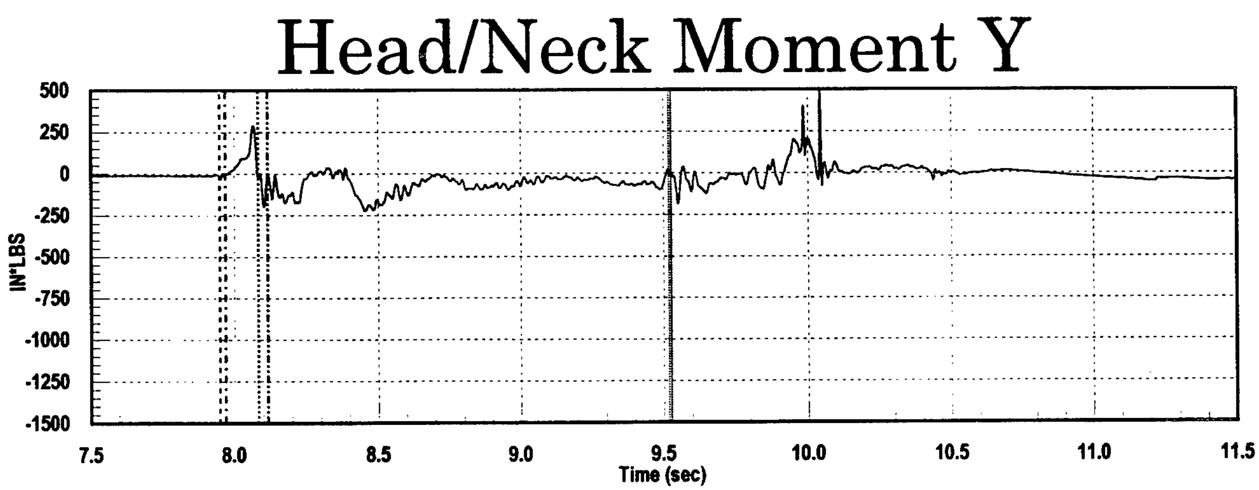
Head/Neck Force Z

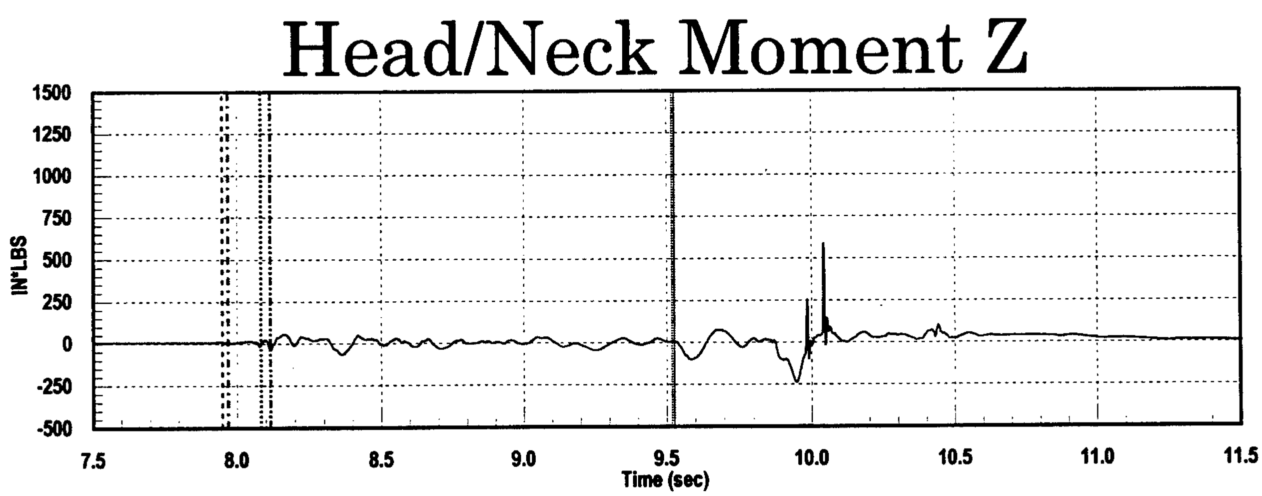


A-10

FL105001, 545 KEAS, 1,800 Feet

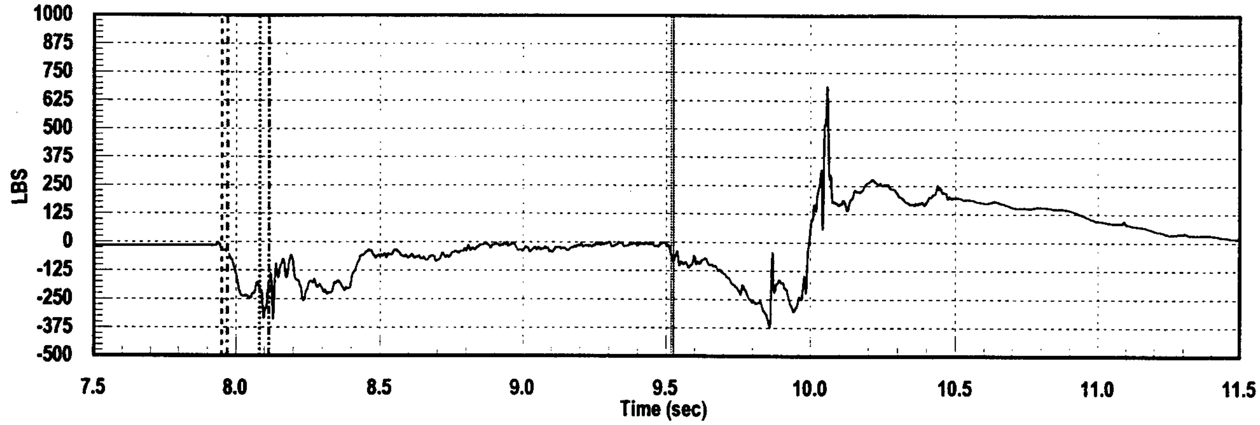




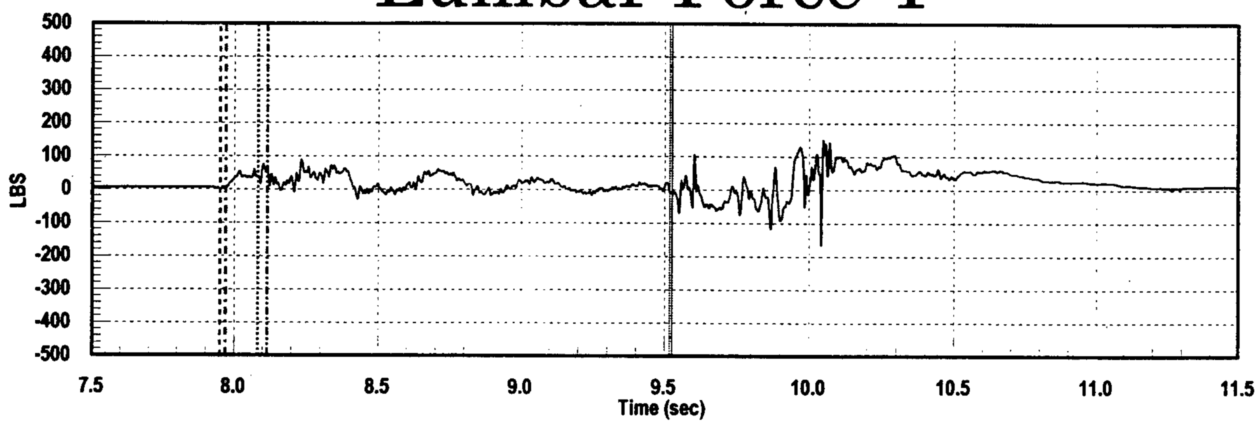


FL105001, 545 KEAS, 1,800 Feet

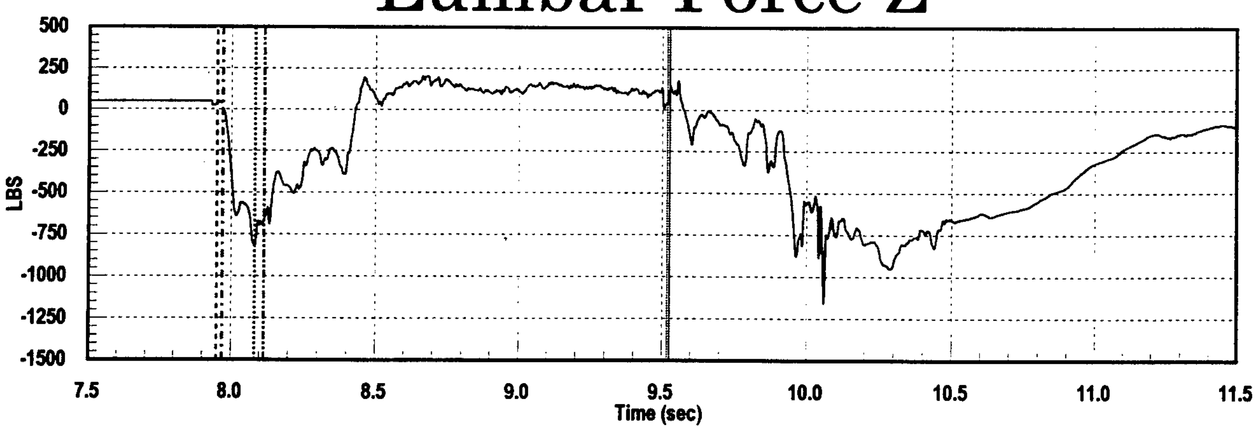
Lumbar Force X



Lumbar Force Y



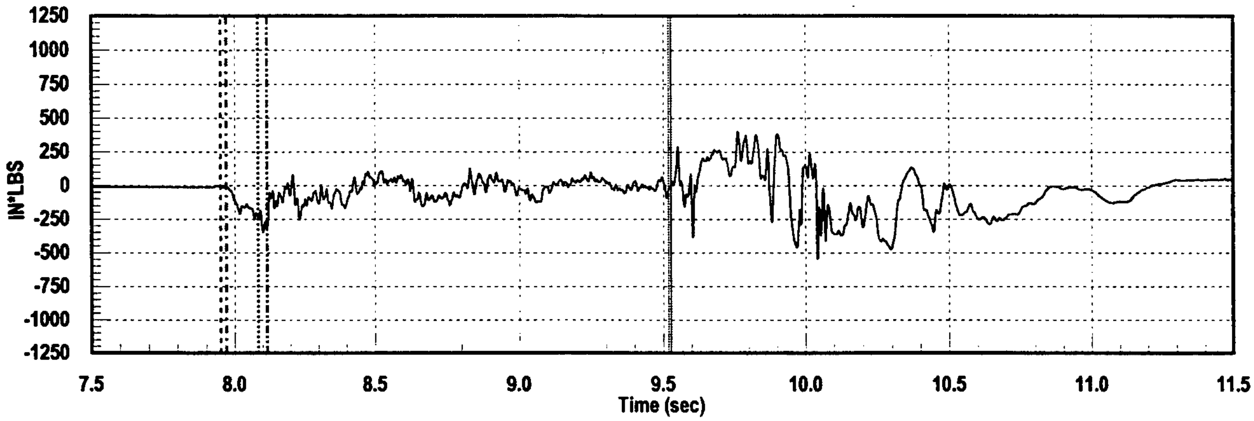
Lumbar Force Z



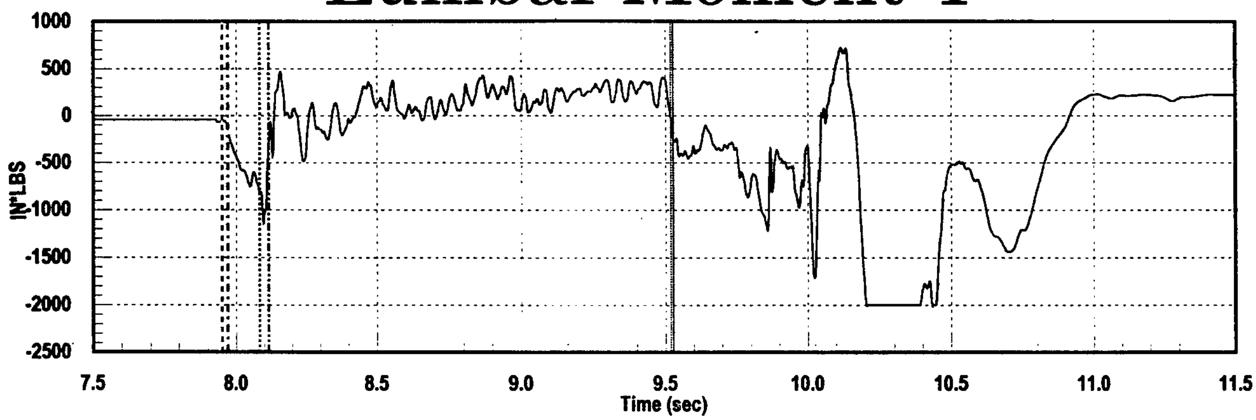
A-12

FL105001, 545 KEAS, 1,800 Feet

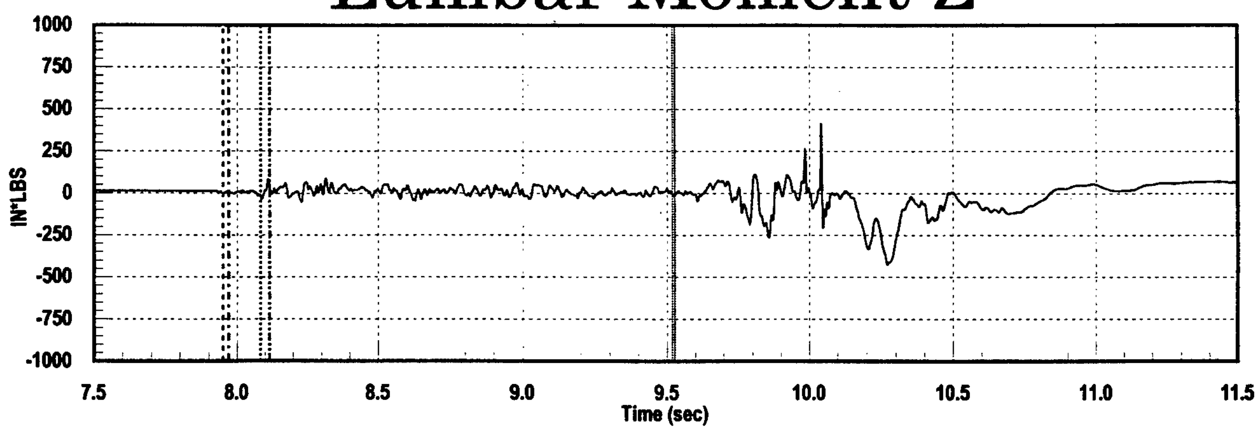
Lumbar Moment X



Lumbar Moment Y



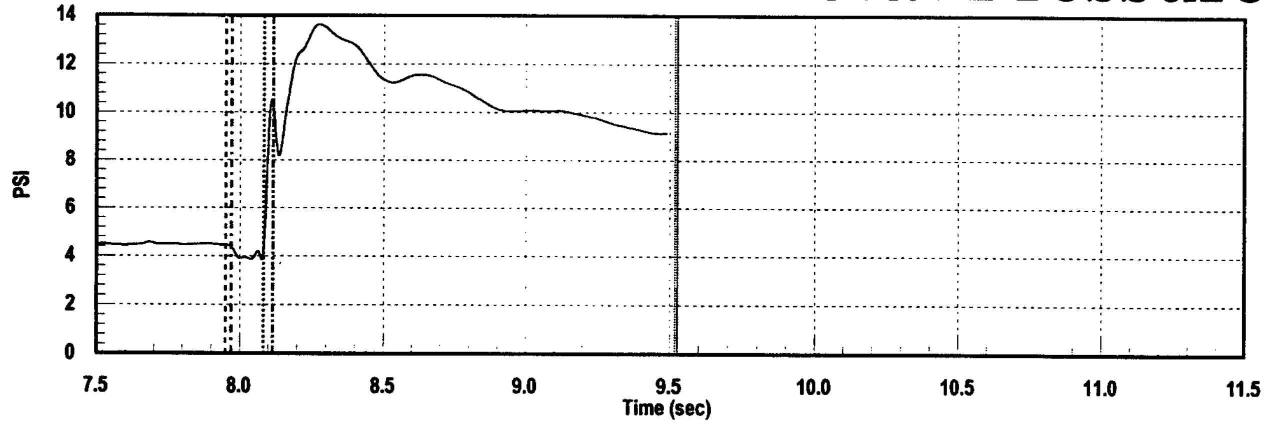
Lumbar Moment Z



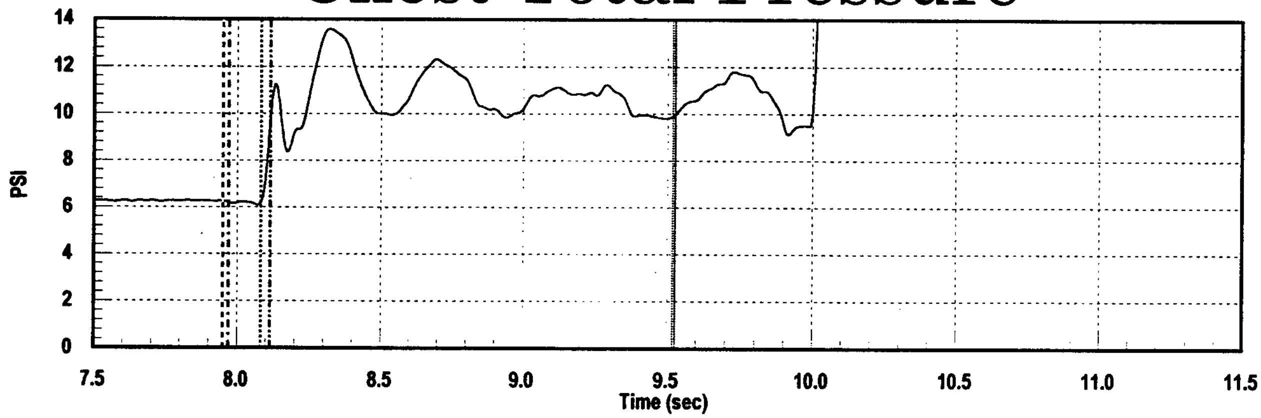
A-13

FL105001, 545 KEAS, 1,800 Feet

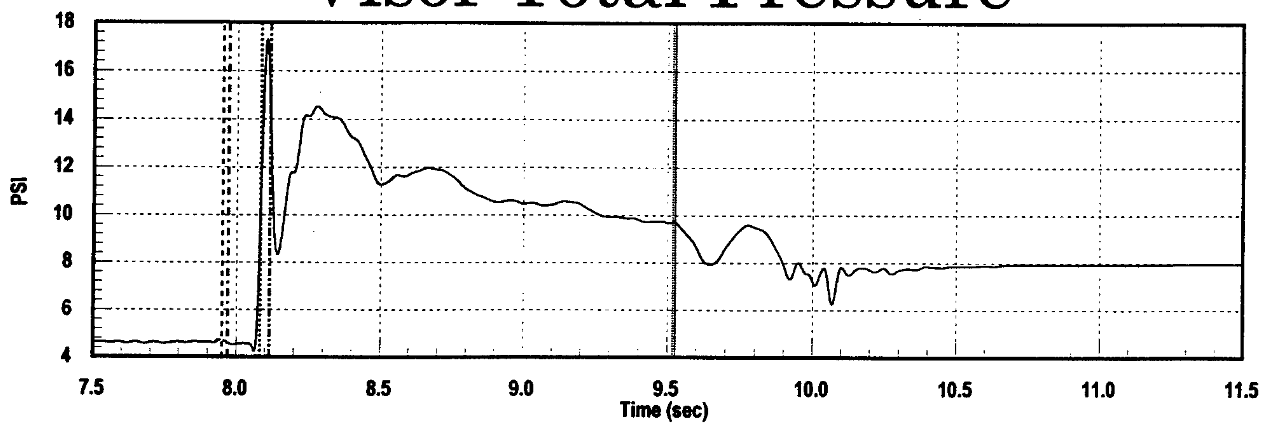
Windblast Deflector Total Pressure



Chest Total Pressure



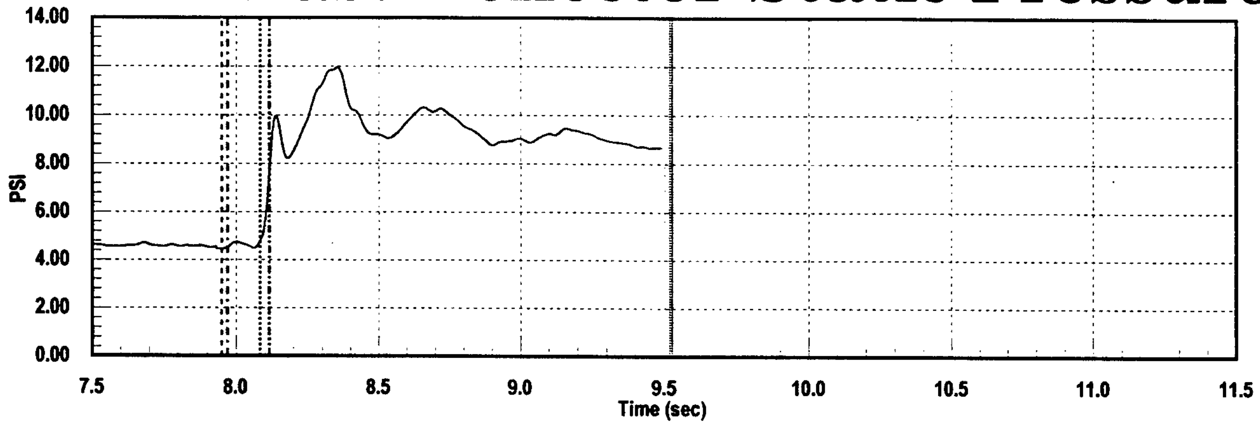
Visor Total Pressure



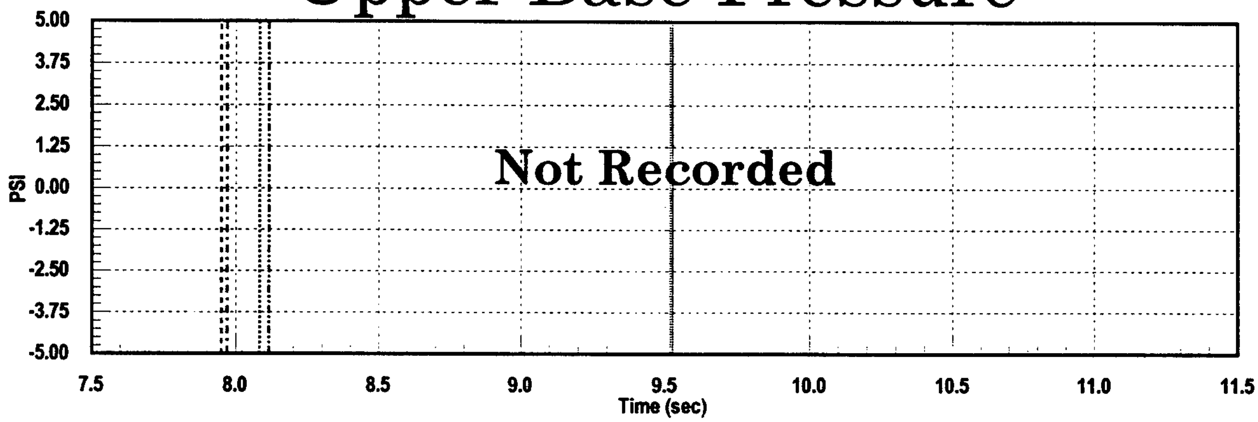
A-14

FL105001, 545 KEAS, 1,800 Feet

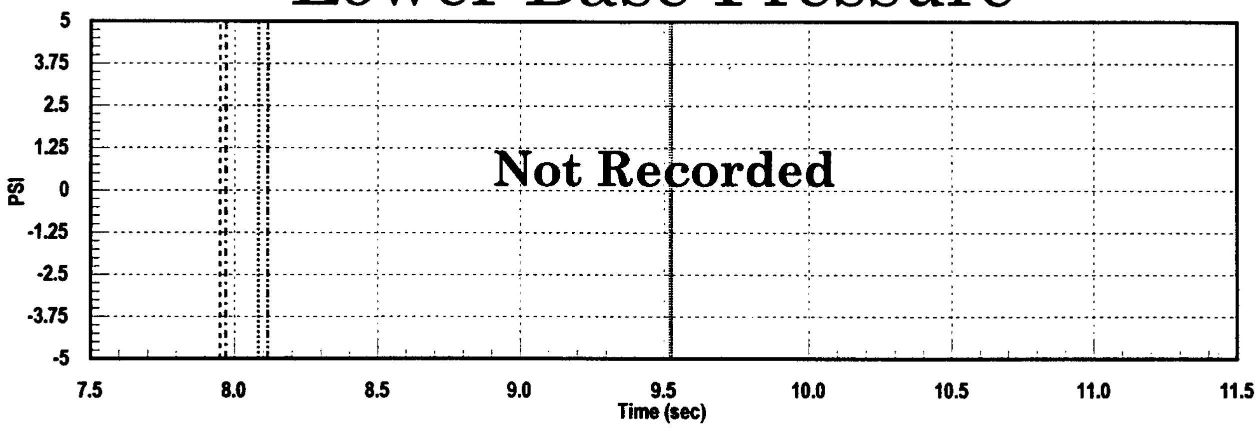
Windblast Deflector Static Pressure



Upper Base Pressure



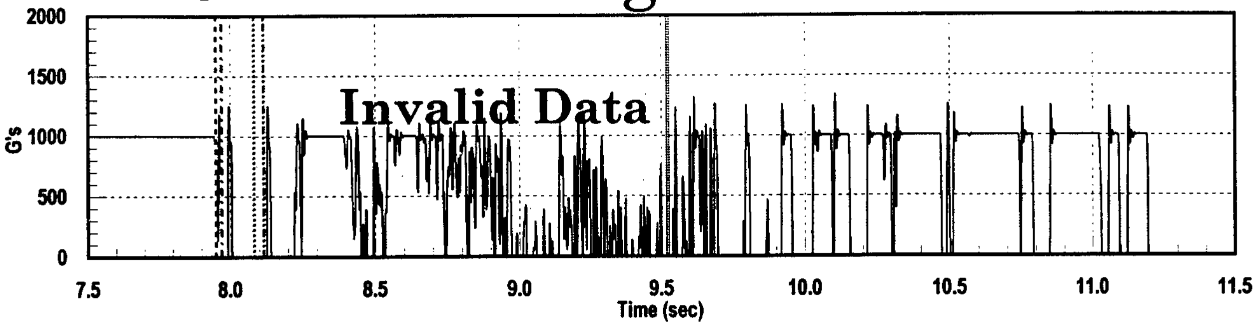
Lower Base Pressure



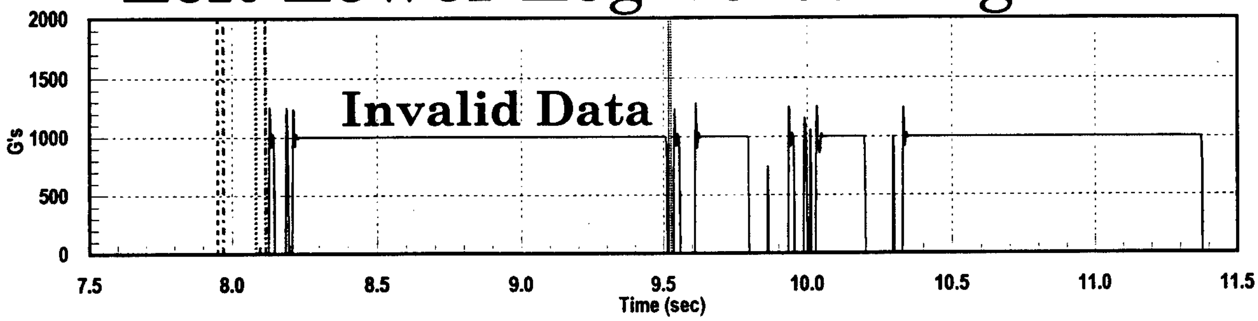
A-15

FL105001, 545 KEAS, 1,800 Feet

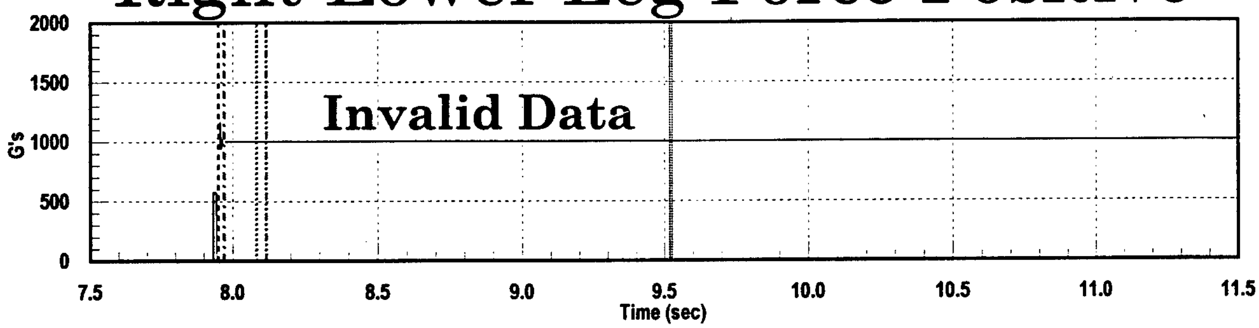
Left Lower Leg Force Positive



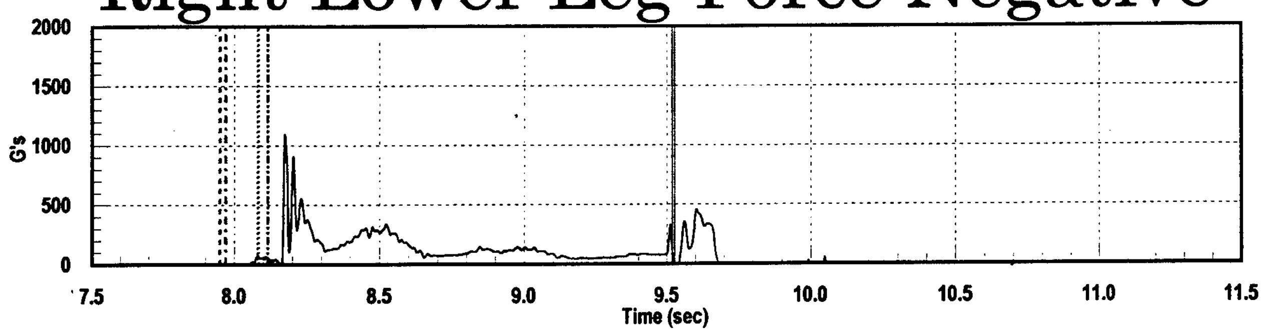
Left Lower Leg Force Negative



Right Lower Leg Force Positive

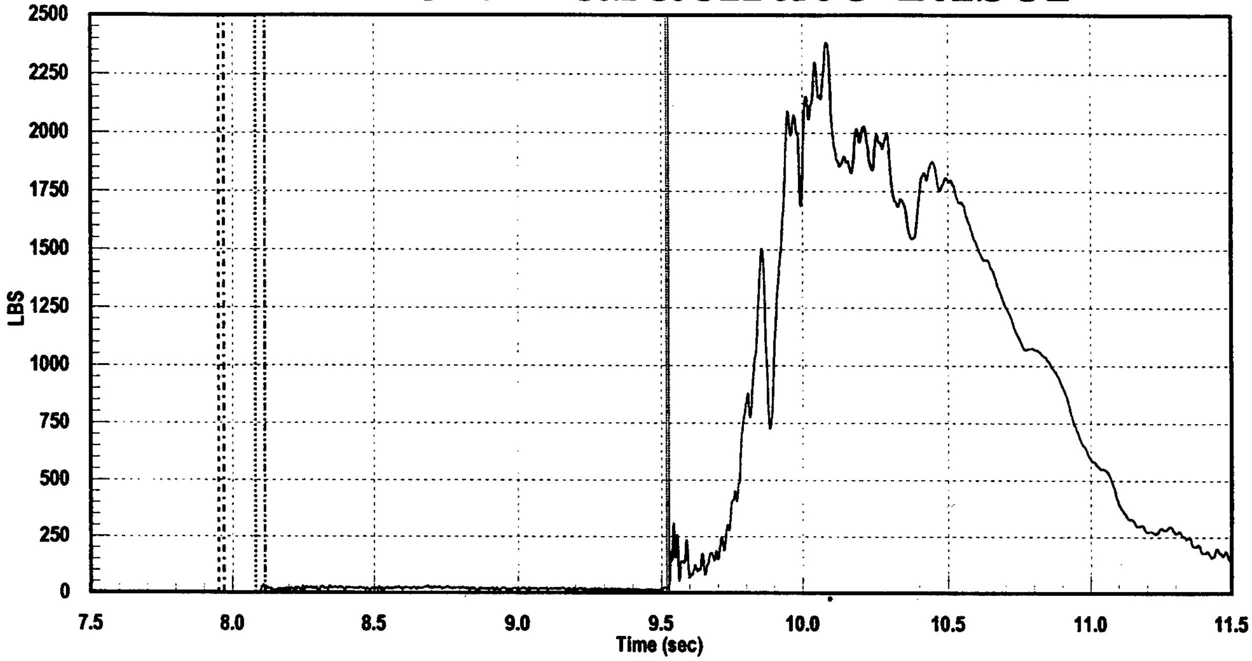


Right Lower Leg Force Negative

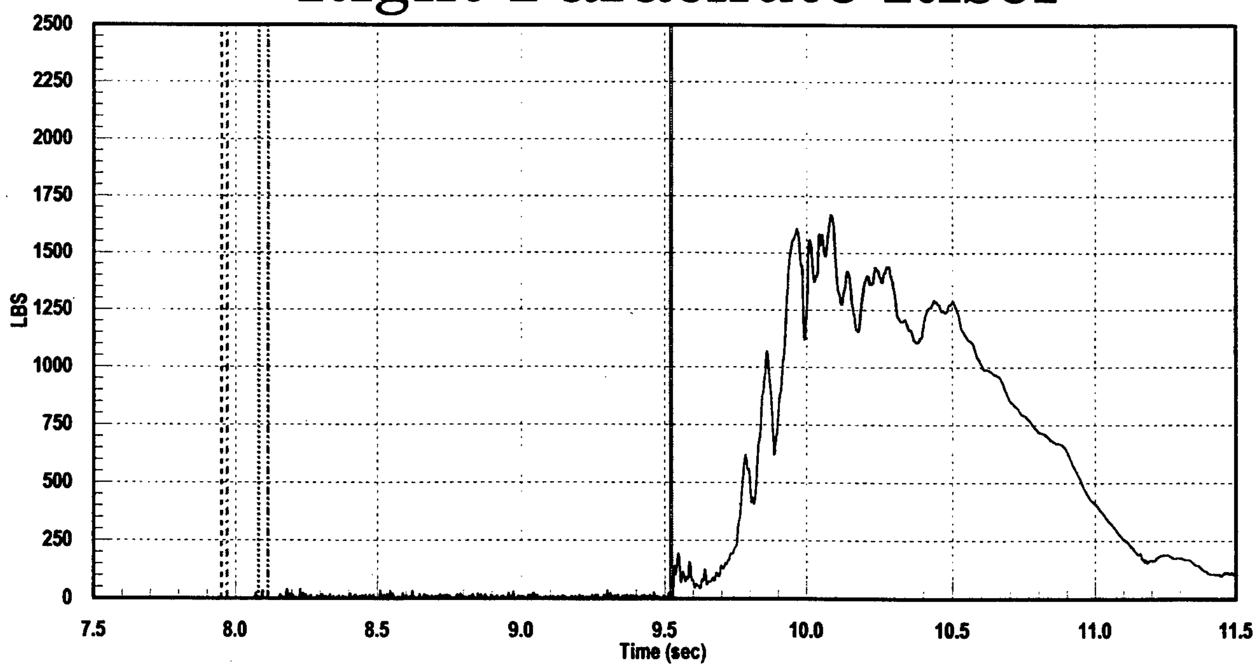


FL105001, 545 KEAS, 1,800 Feet

Left Parachute Riser

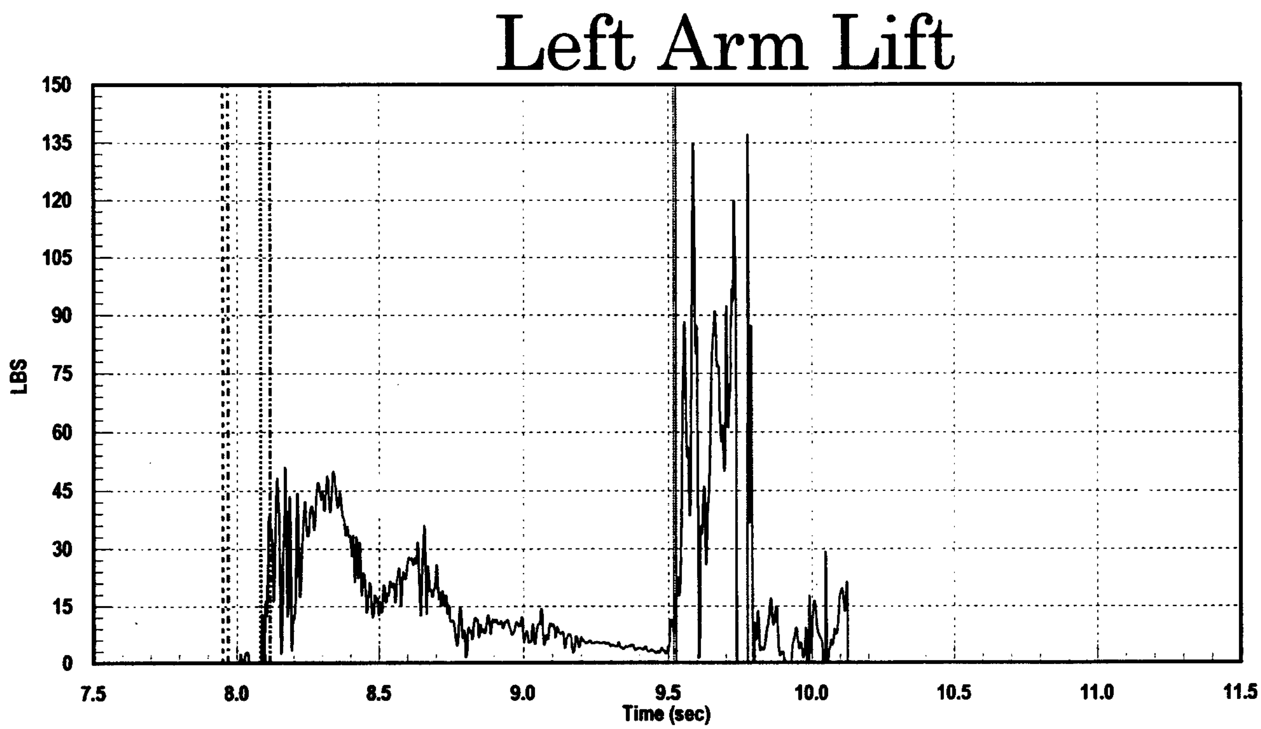


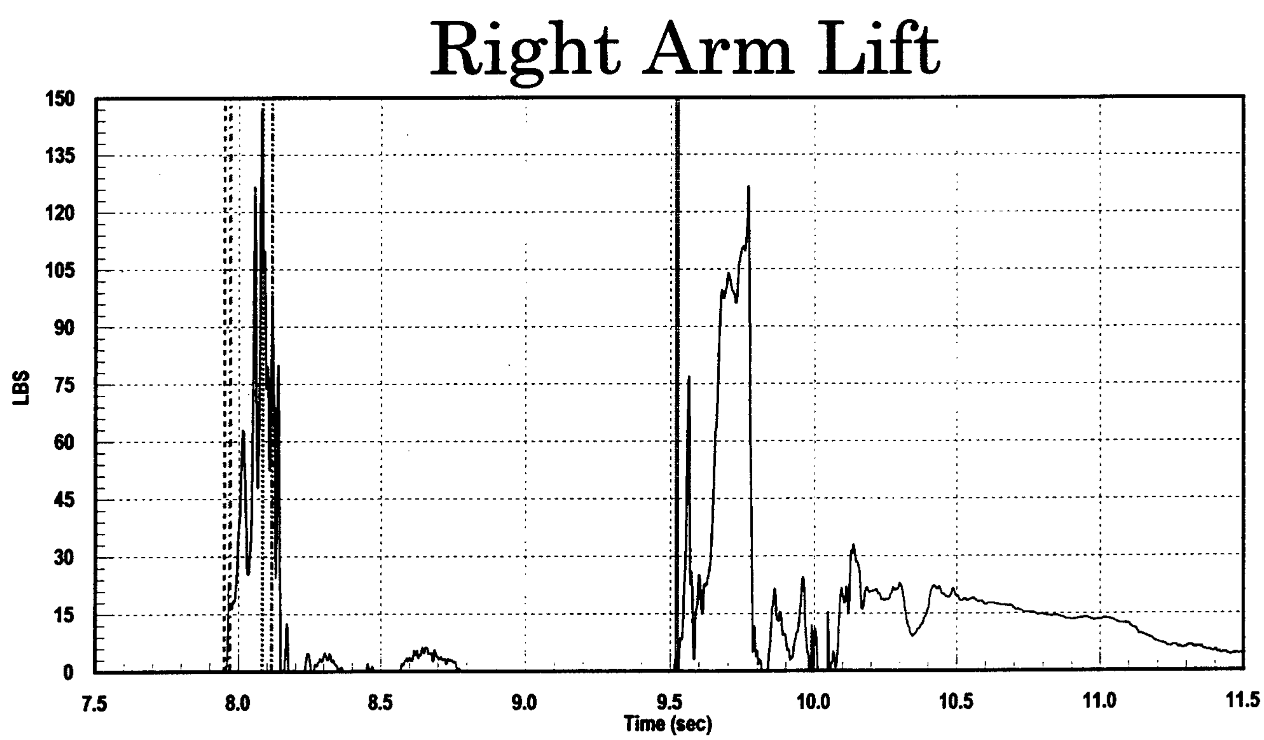
Right Parachute Riser



A-17

FL105001, 545 KEAS, 1,800 Feet

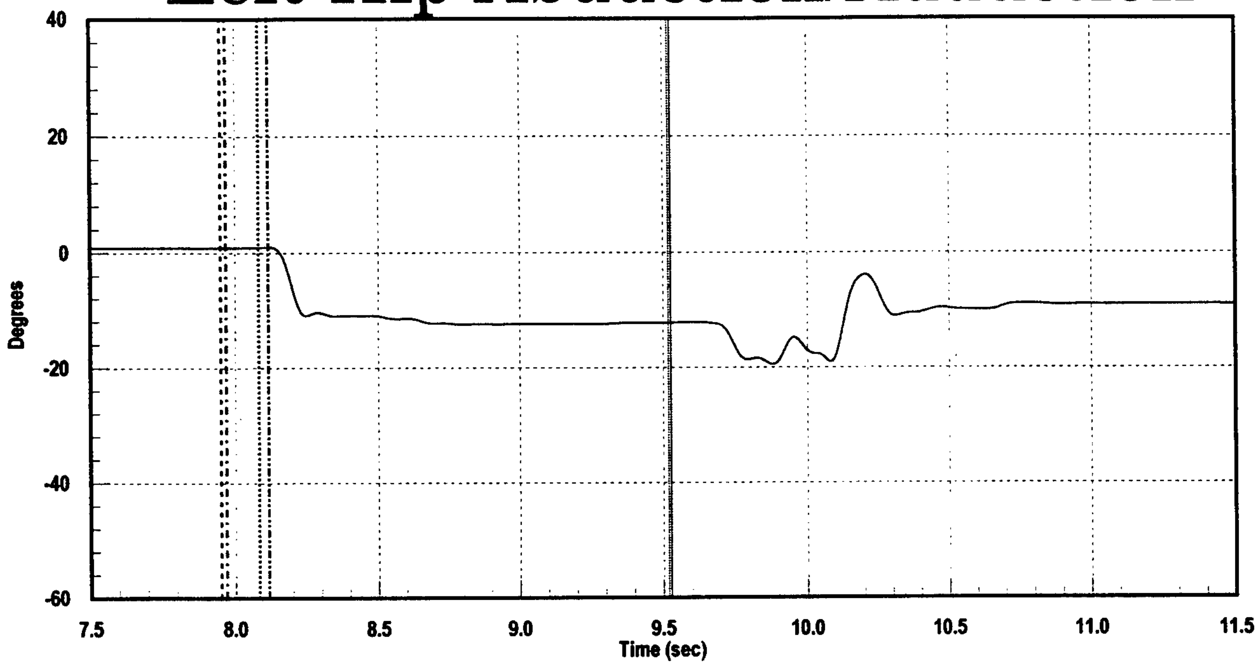




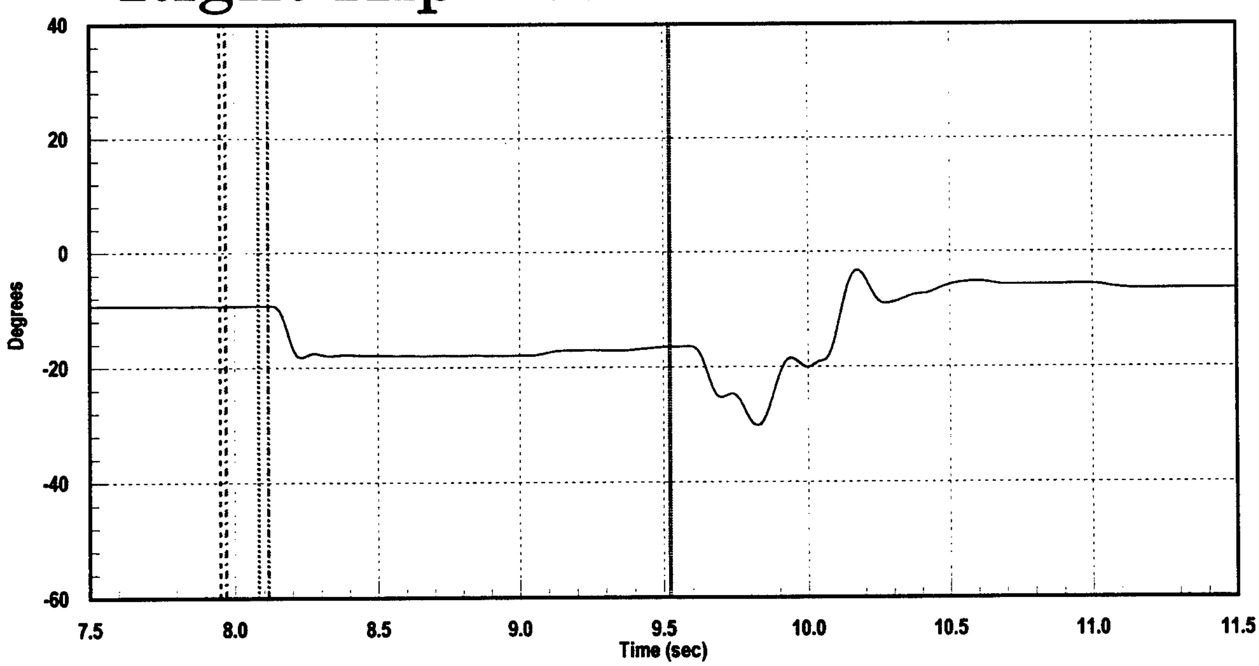
A-18

FL105001, 545 KEAS, 1,800 Feet

Left Hip Abduction/Adduction

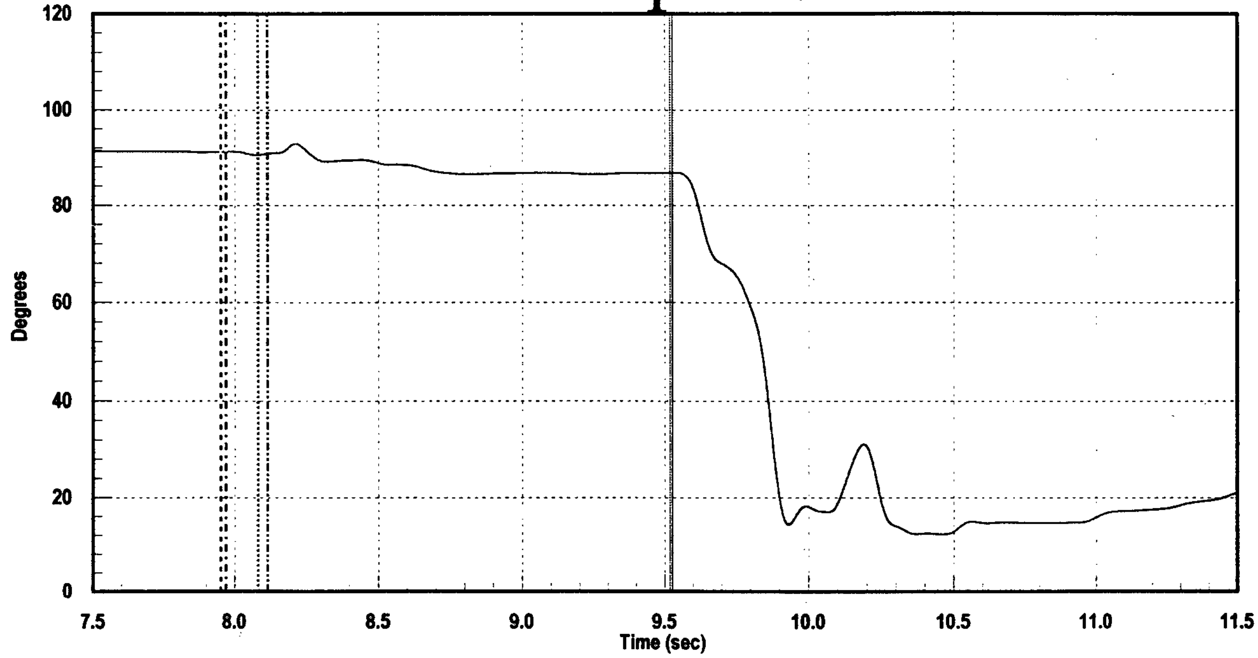


Right Hip Abduction/Adduction

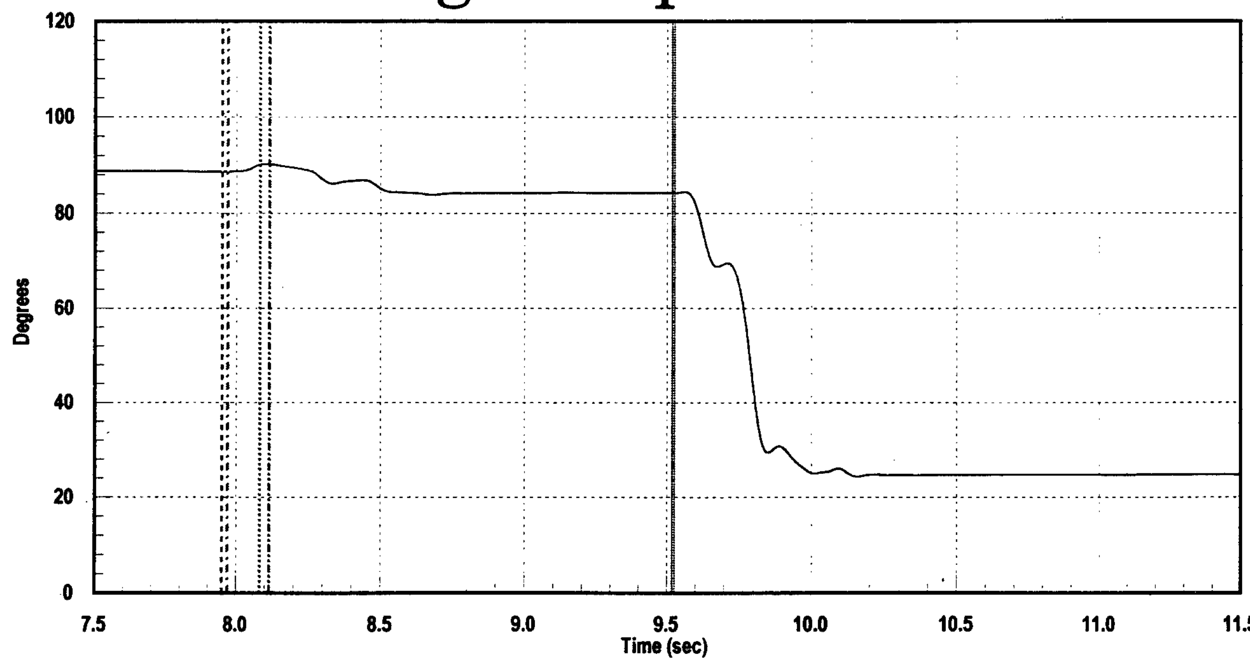


FL105001, 545 KEAS, 1,800 Feet

Left Hip Flexion

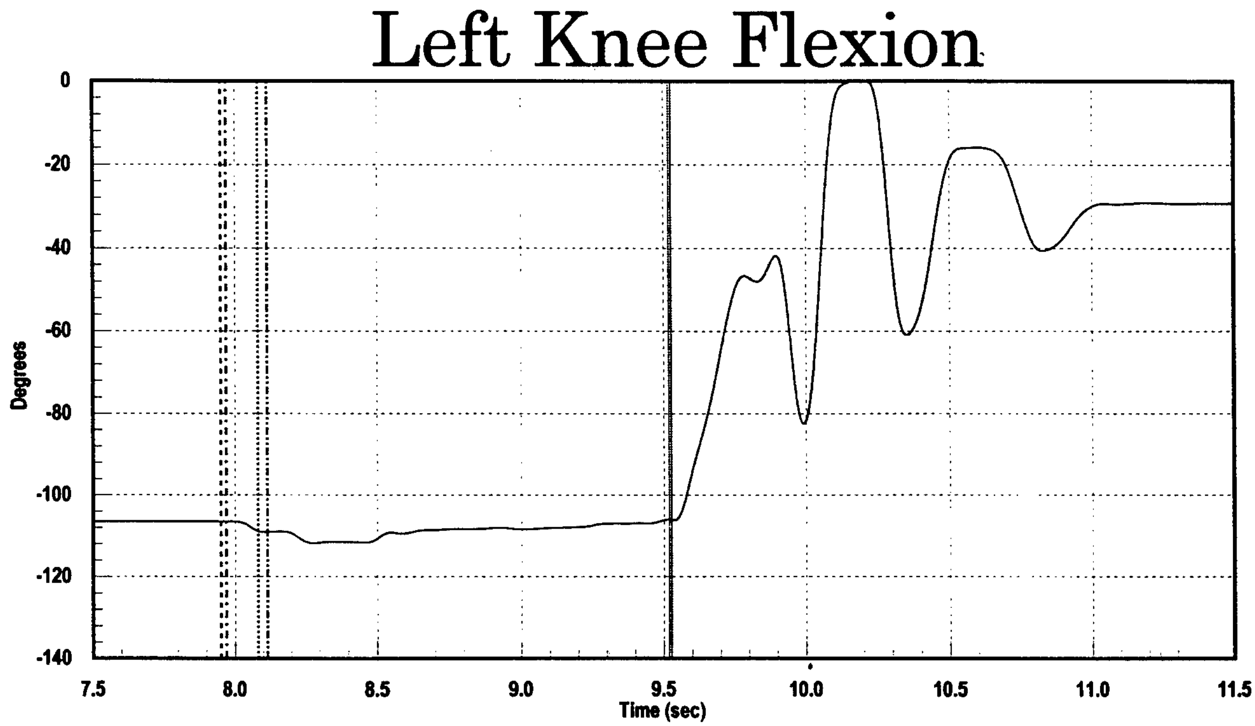


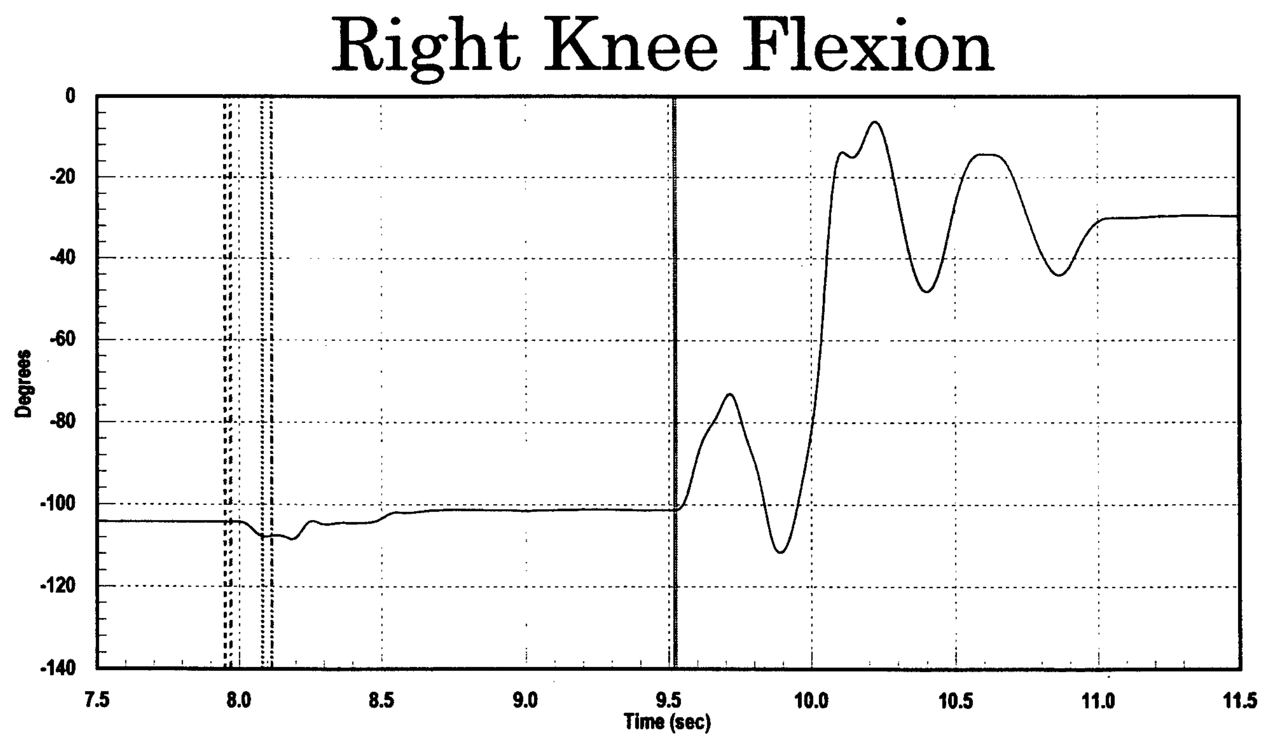
Right Hip Flexion



A-20

FL105001, 545 KEAS, 1,800 Feet

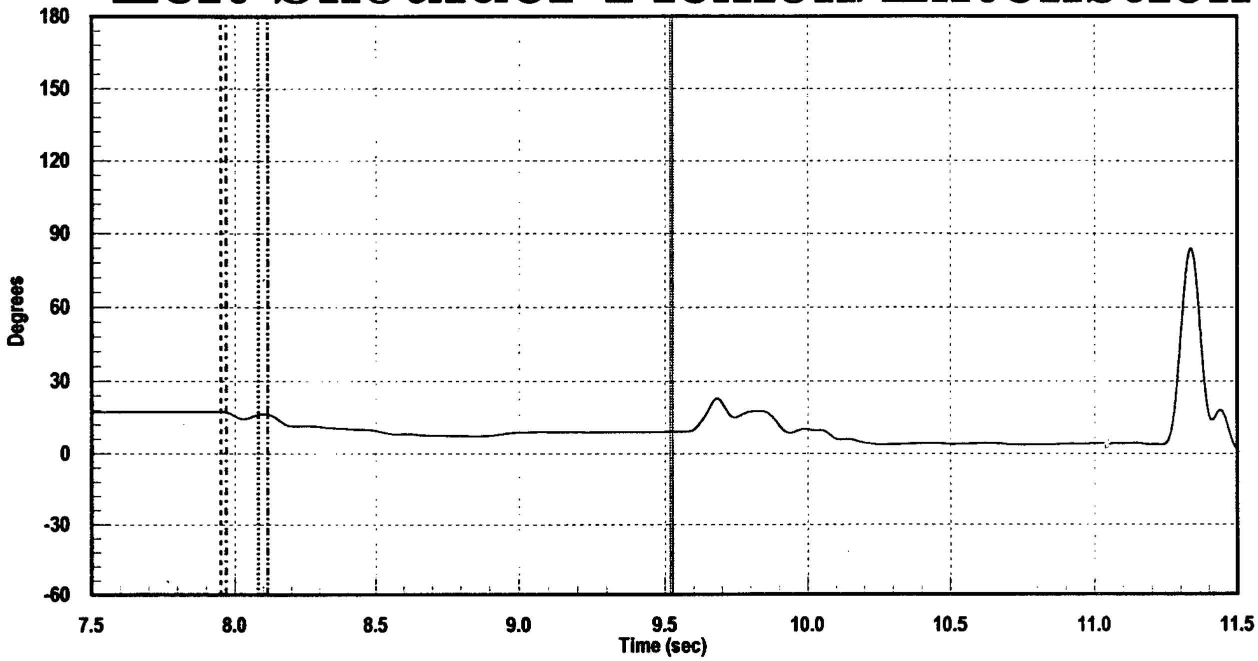




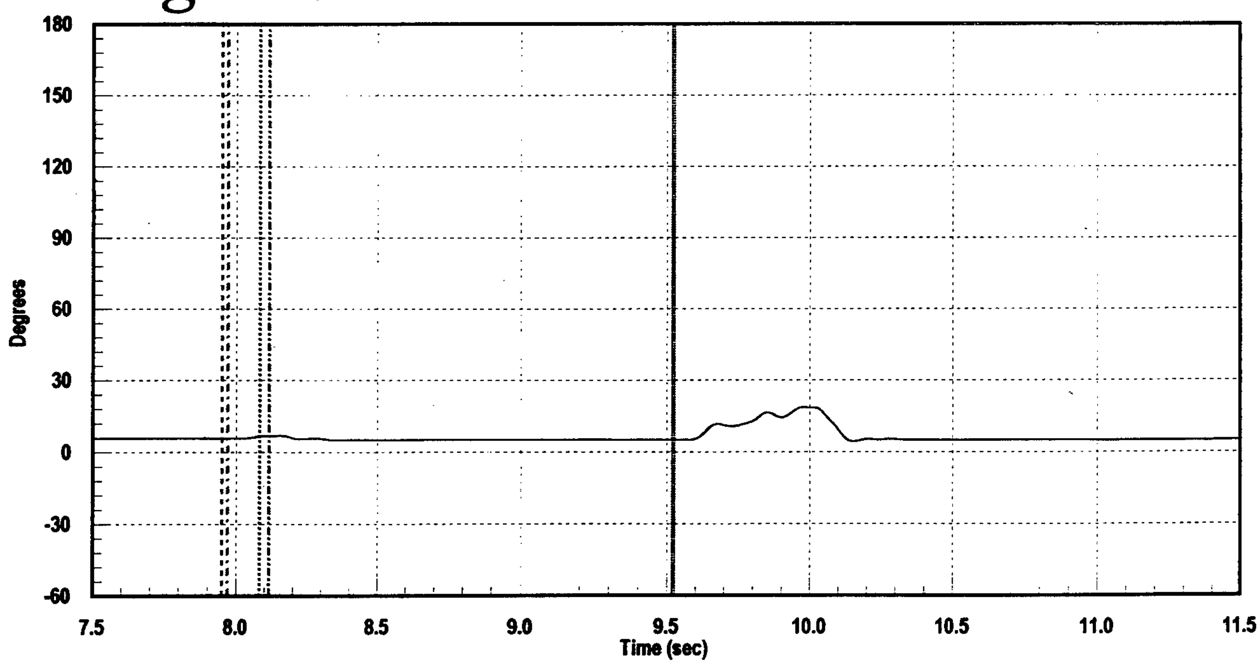
A-21

FL105001, 545 KEAS, 1,800 Feet

Left Shoulder Flexion/Extenstion



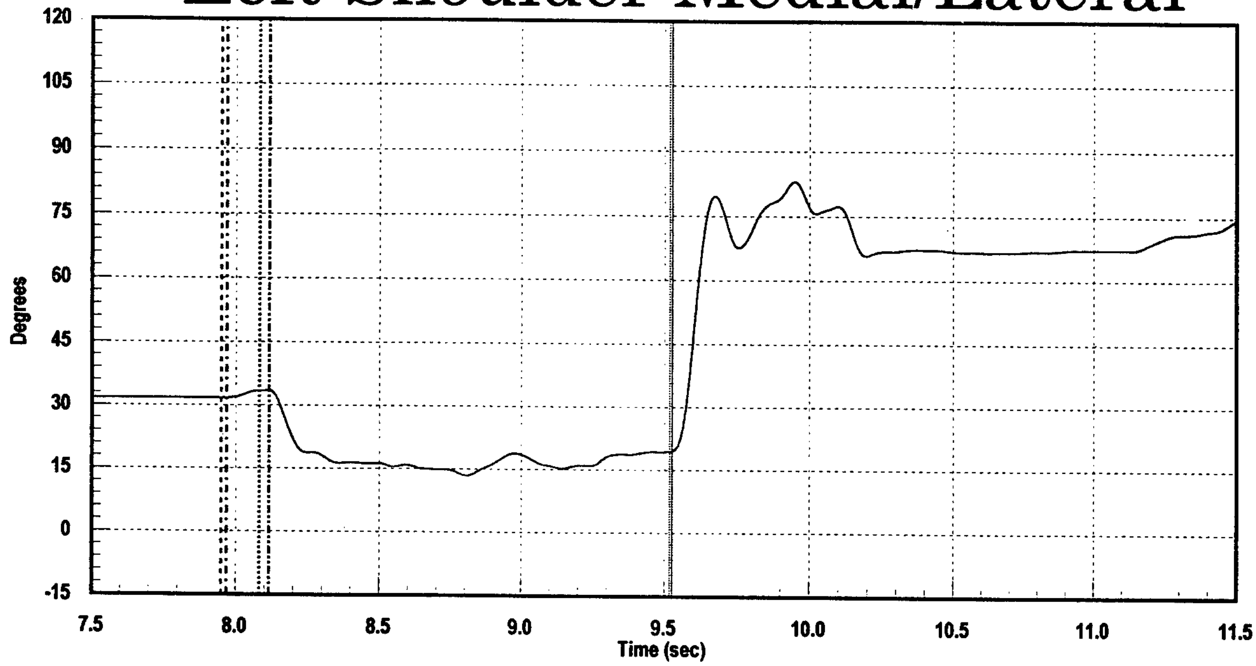
Right Shoulder Flexion/Extension



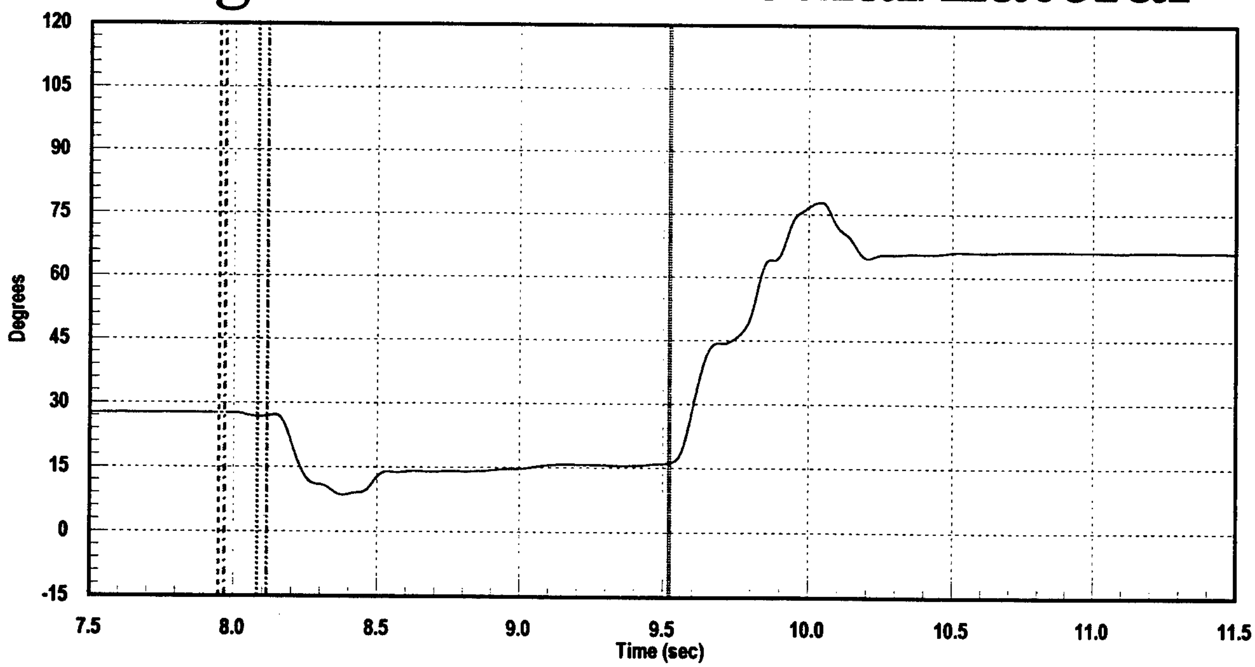
A-22

FL105001, 545 KEAS, 1,800 Feet

Left Shoulder Medial/Lateral



Right Shoulder Medial/Lateral

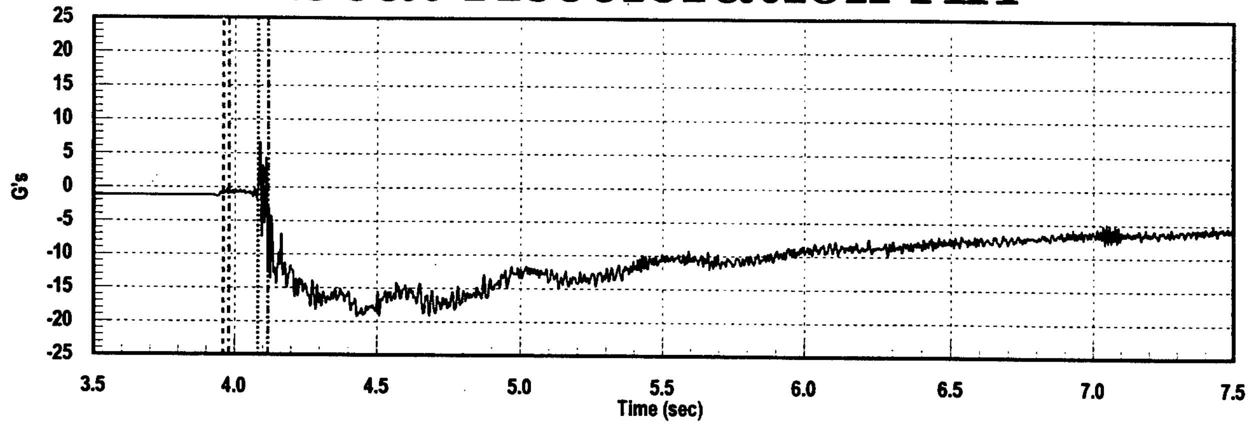


FL103012, 510 KEAS, 46,000 Ft
Processed Data

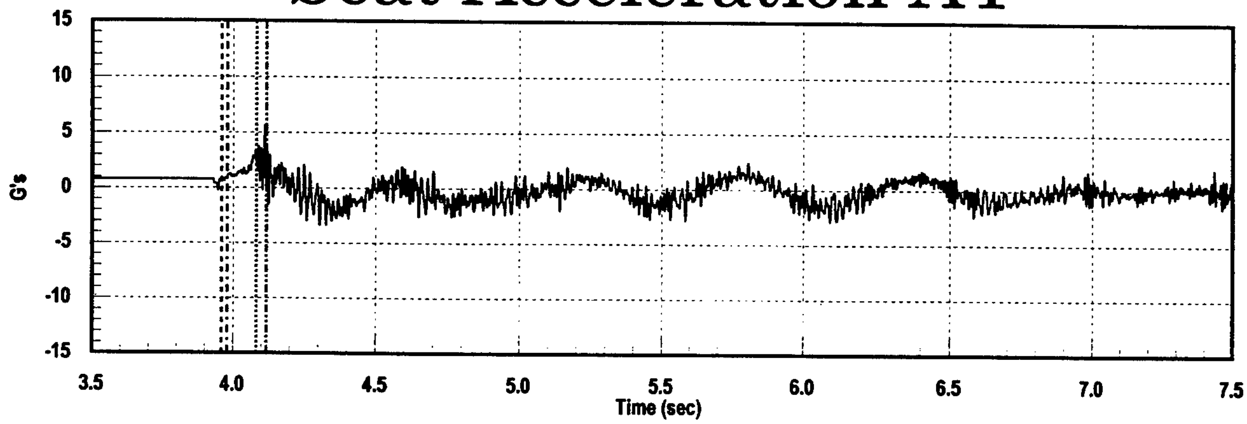
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL103012, 510 KEAS, 46,000 Ft

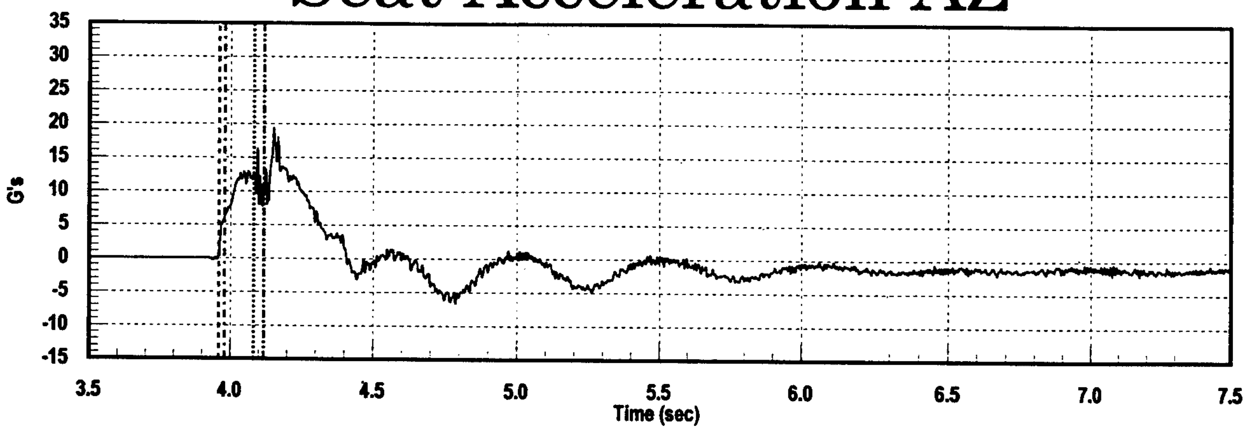
Seat Acceleration AX



Seat Acceleration AY

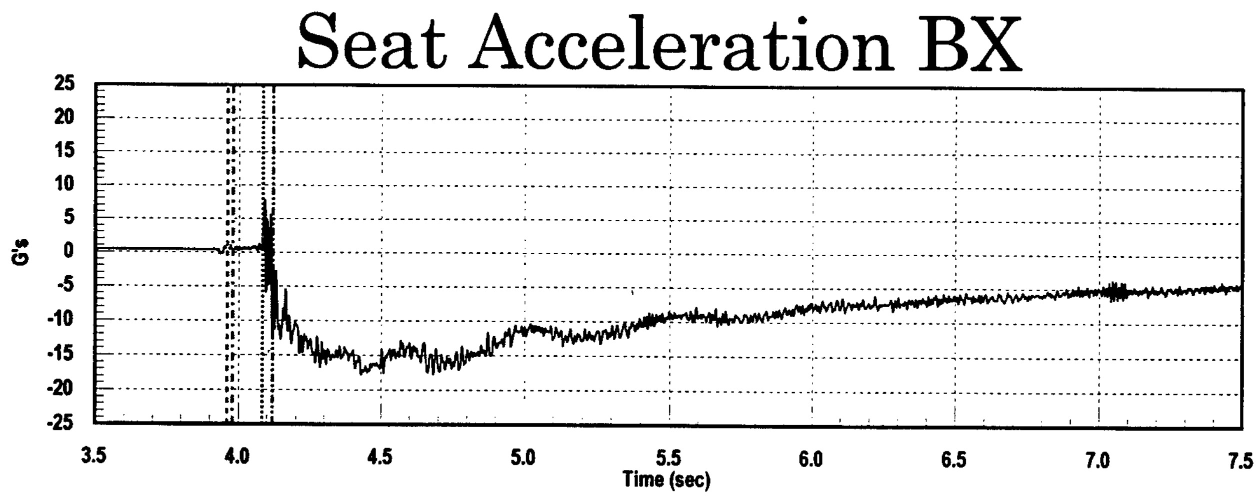


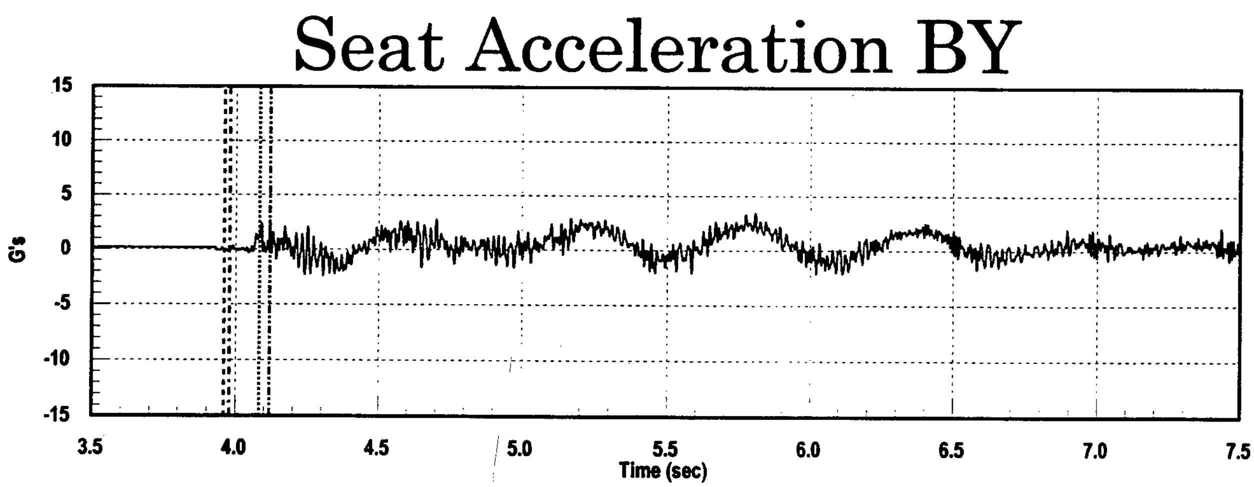
Seat Acceleration AZ

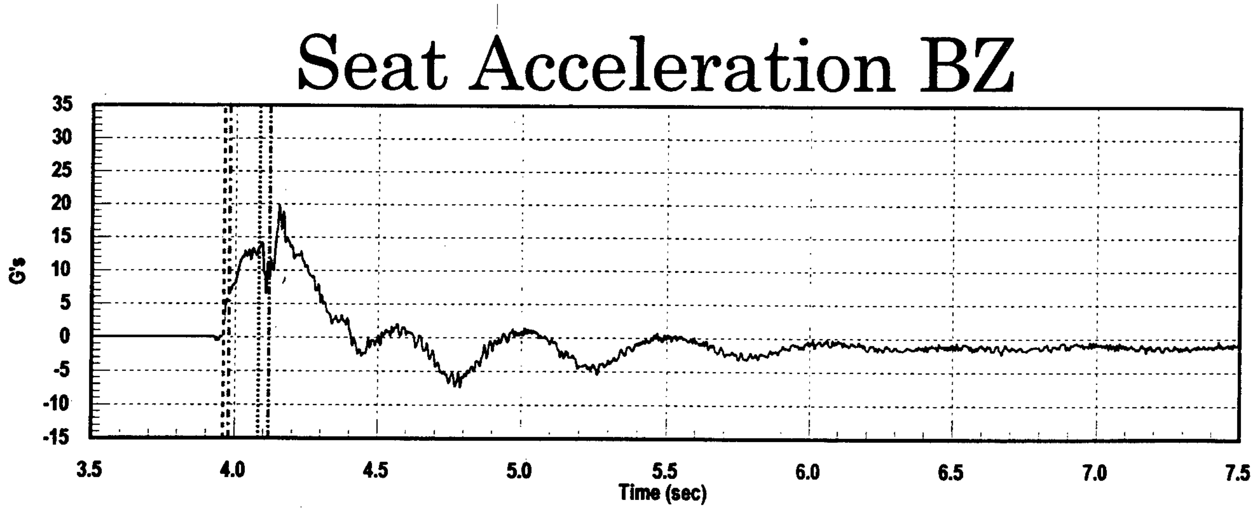


A-1

FL103012, 510 KEAS, 46,000 Ft



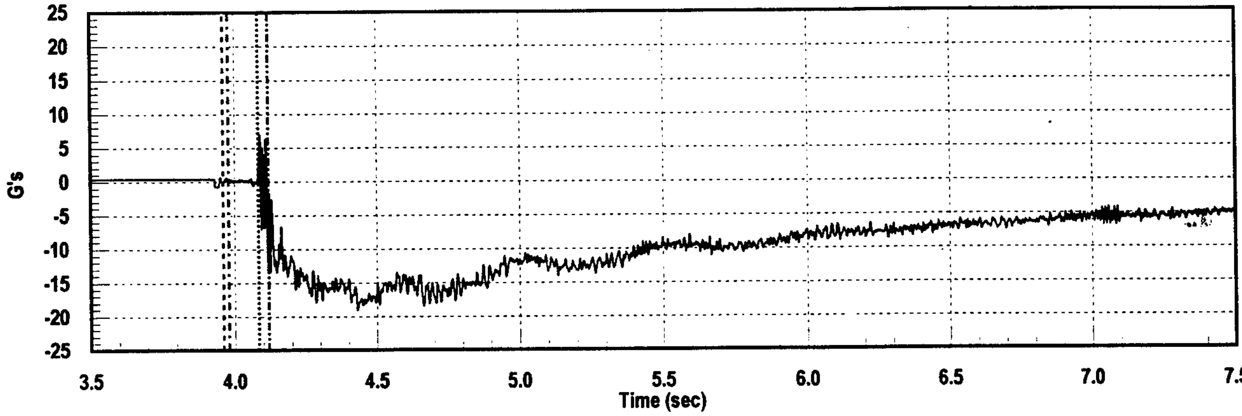




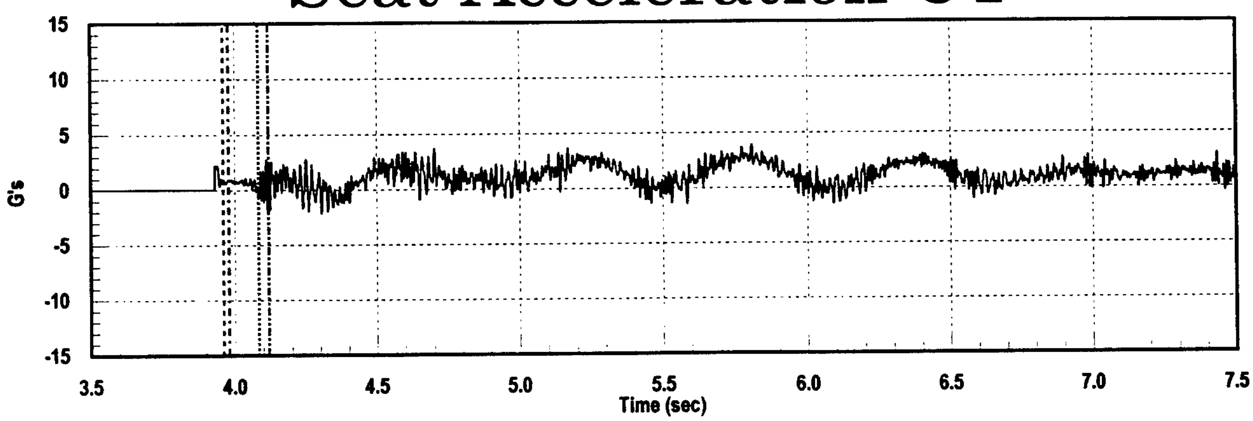
A-2

FL103012, 510 KEAS, 46,000 Ft

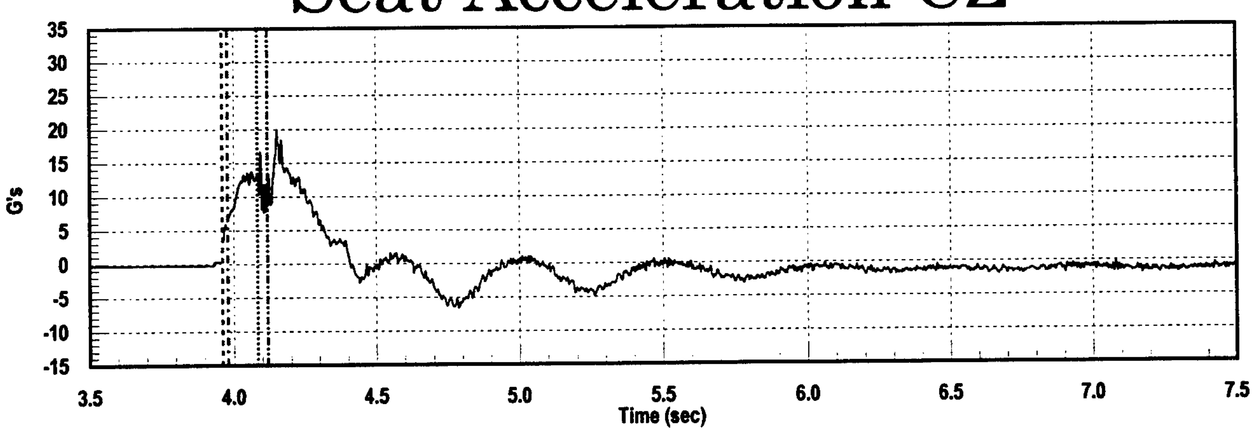
Seat Acceleration CX



Seat Acceleration CY



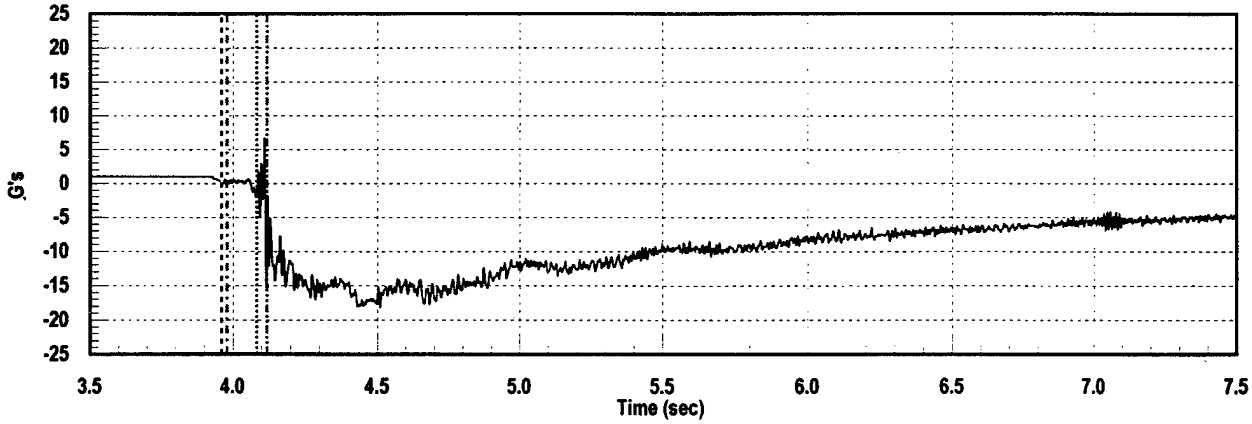
Seat Acceleration CZ



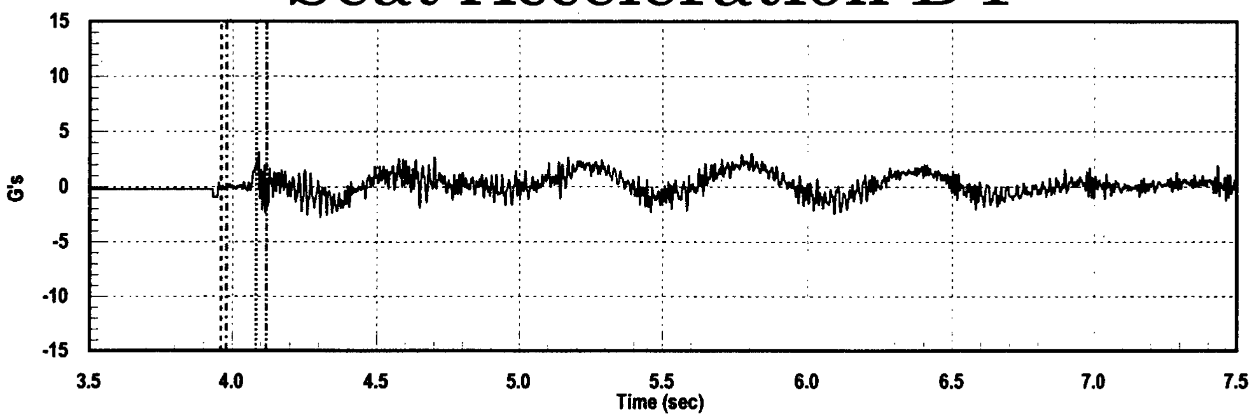
A-3

FL103012, 510 KEAS, 46,000 Ft

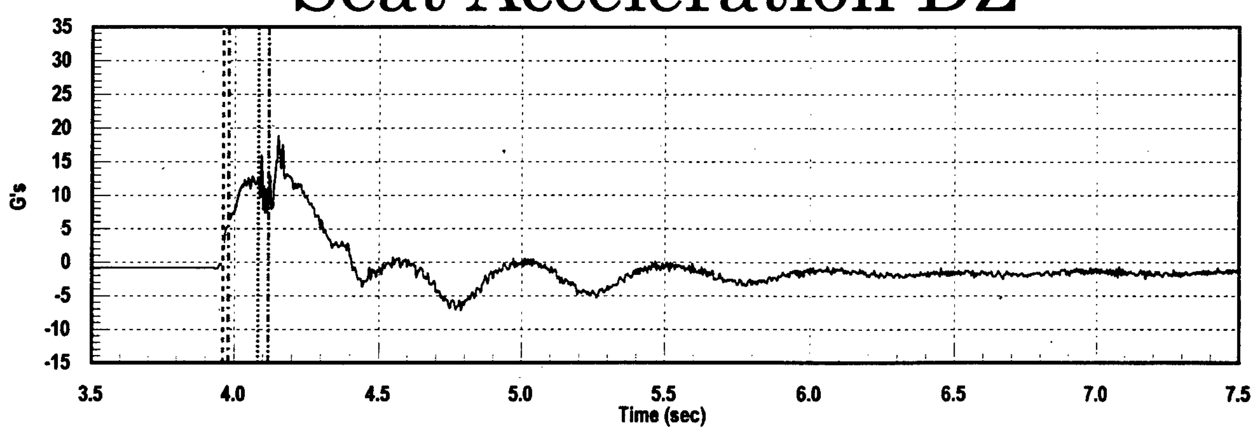
Seat Acceleration DX



Seat Acceleration DY



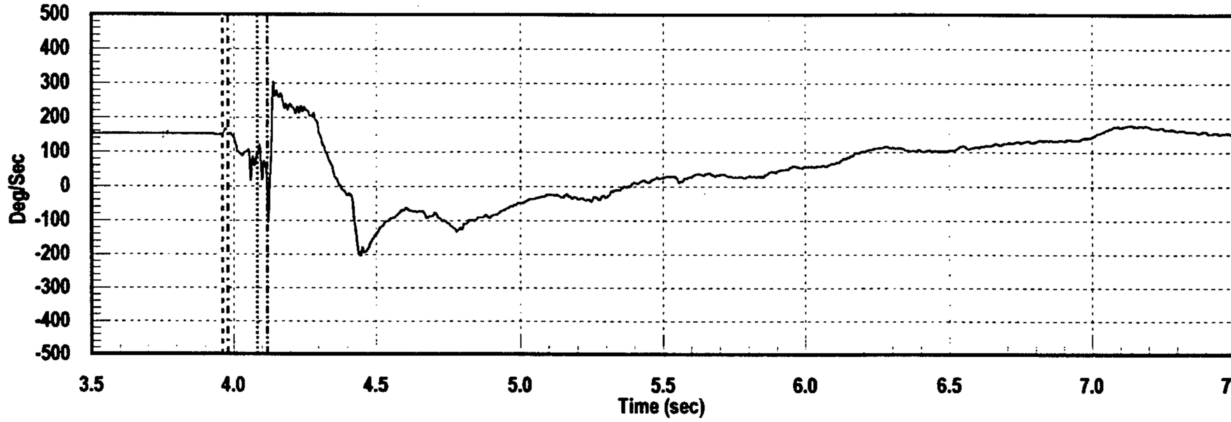
Seat Acceleration DZ



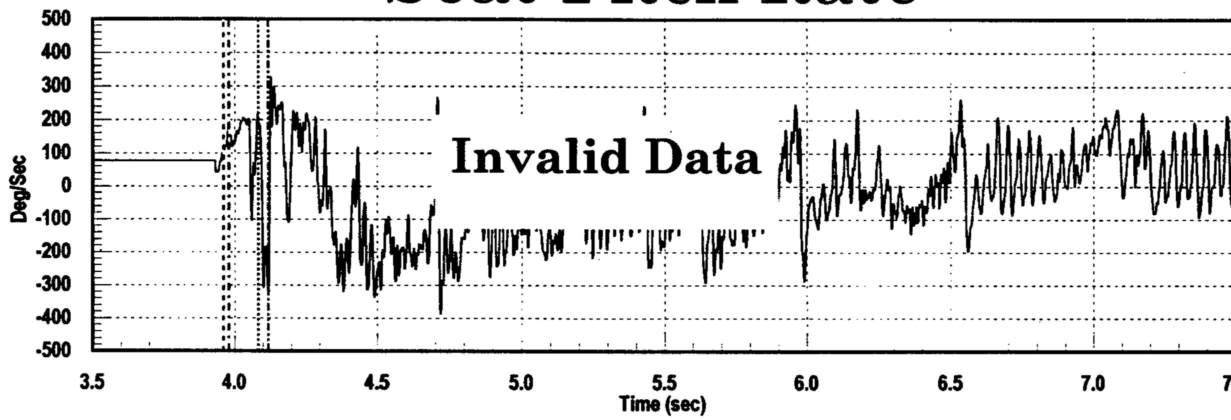
A-4

FL103012, 510 KEAS, 46,000 Ft

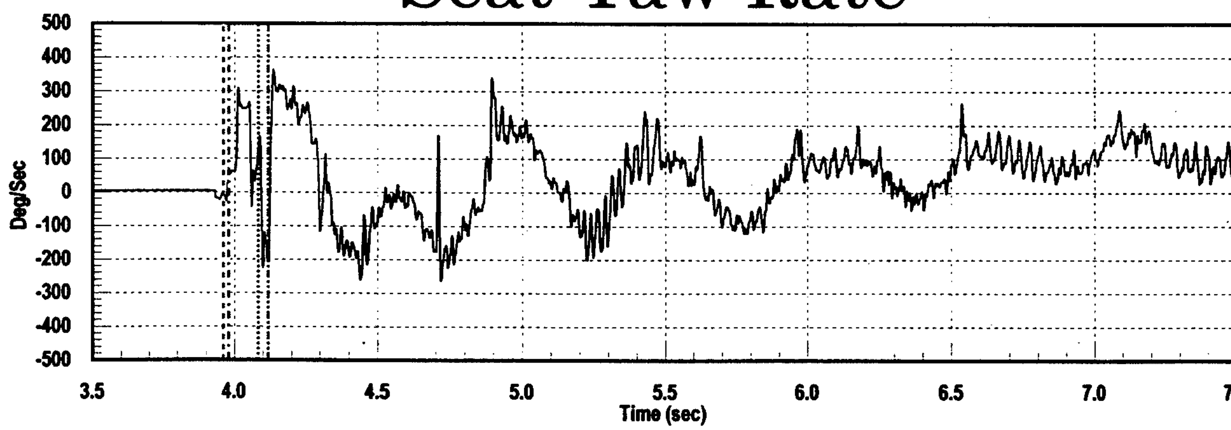
Seat Roll Rate



Seat Pitch Rate

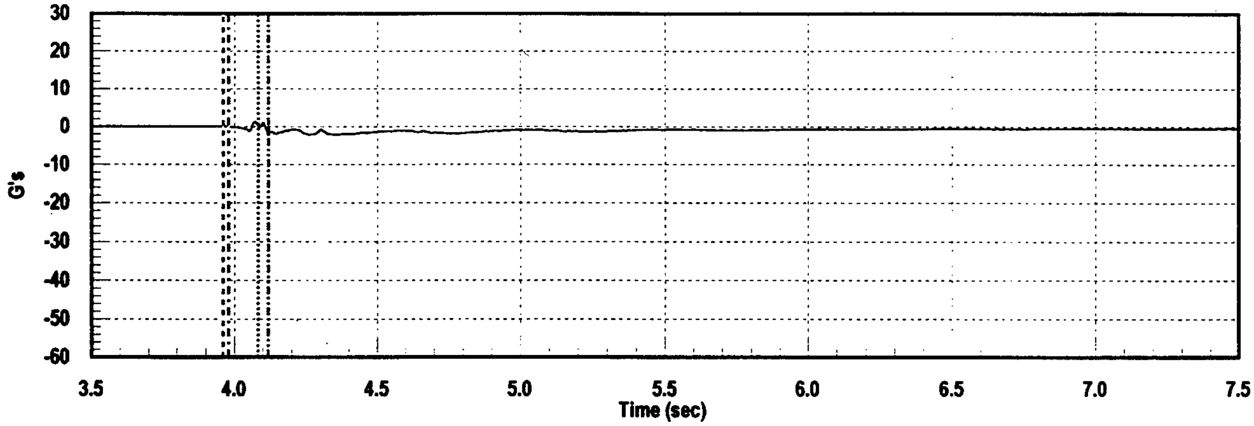


Seat Yaw Rate

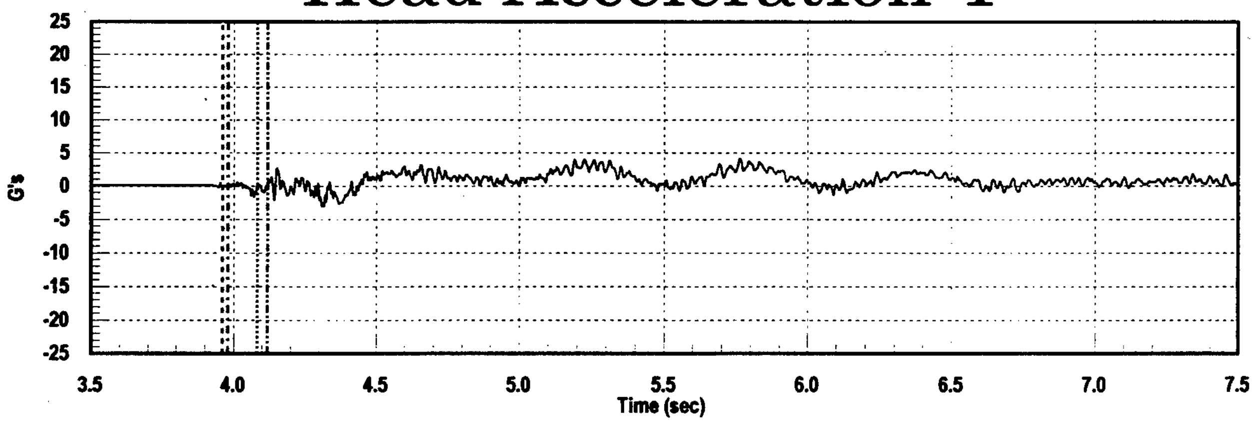


FL103012, 510 KEAS, 46,000 Ft

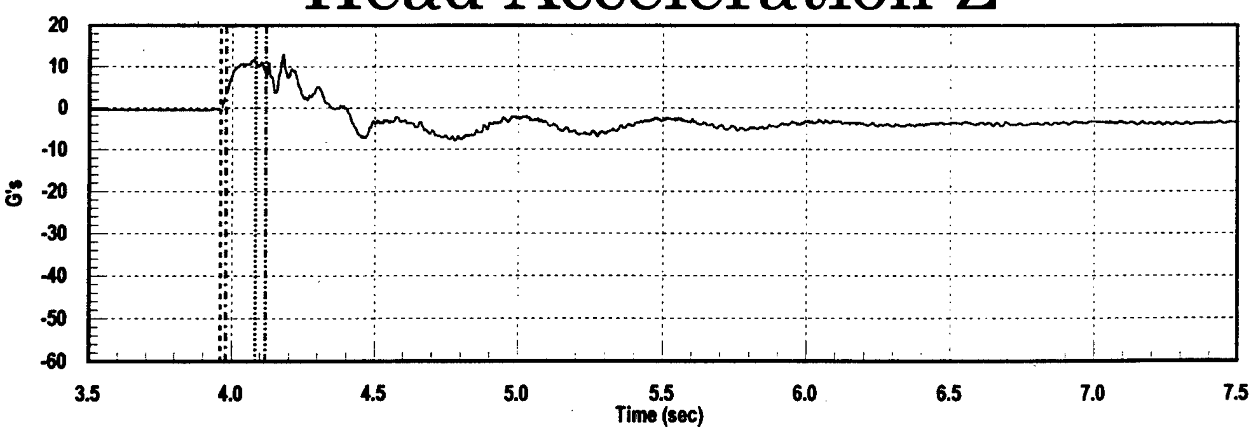
Head Acceleration X



Head Acceleration Y



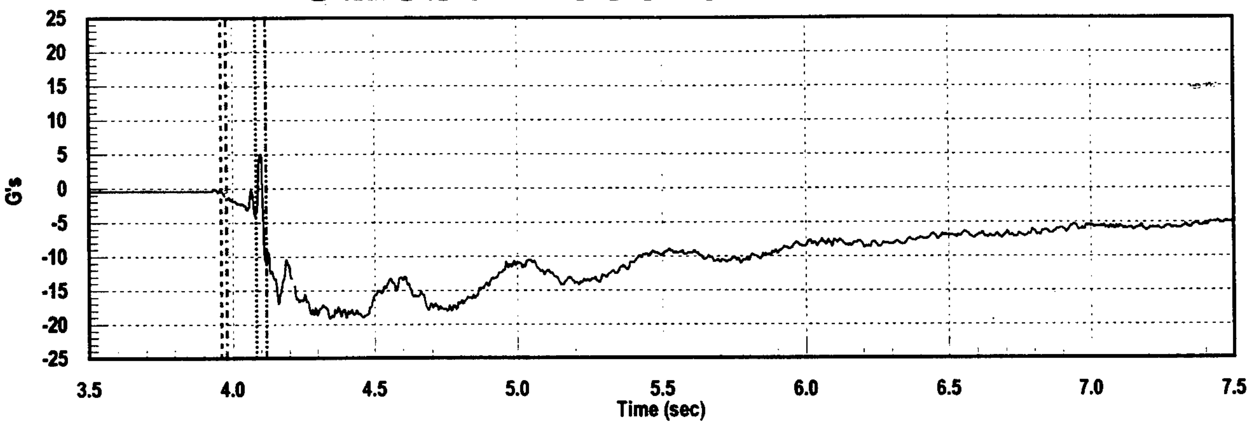
Head Acceleration Z



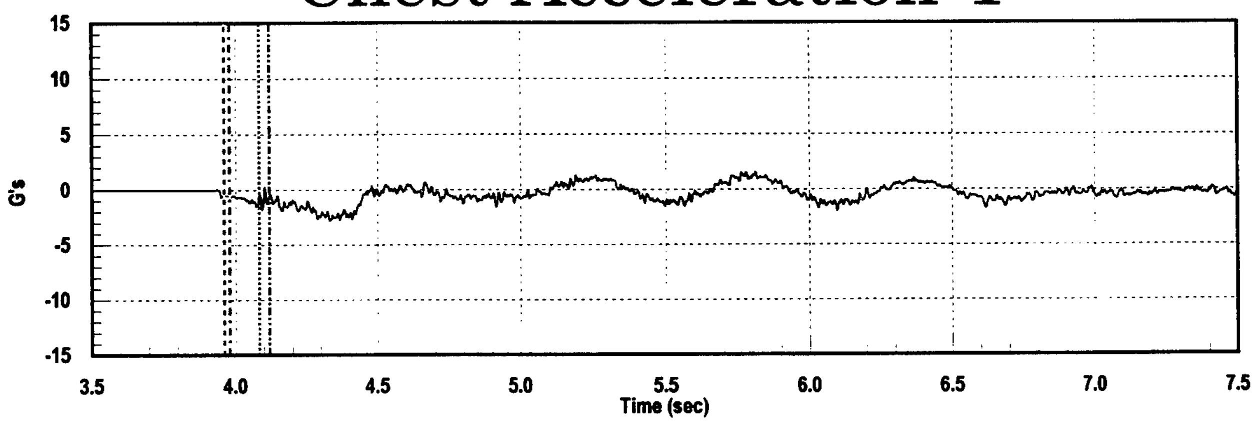
A-6

FL103012, 510 KEAS, 46,000 Ft

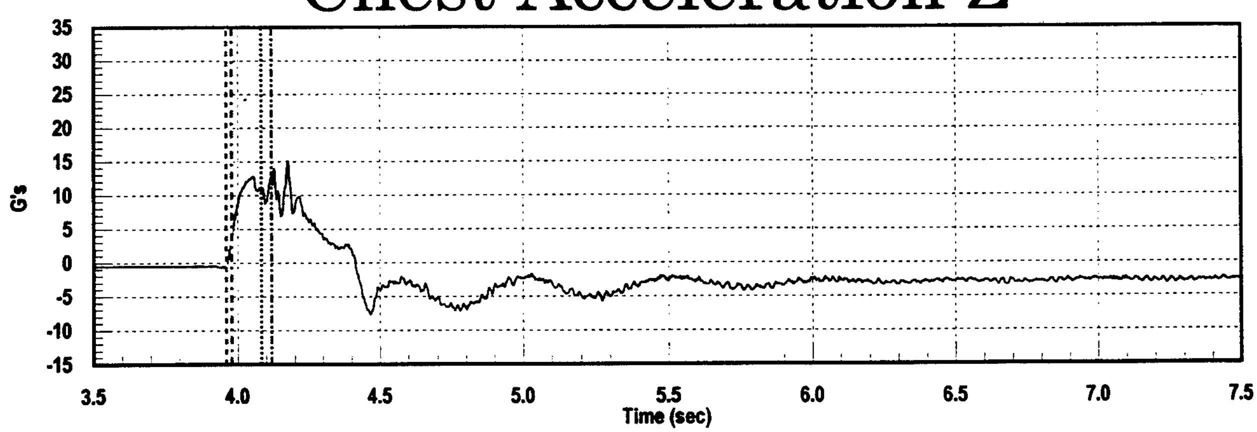
Chest Acceleration X



Chest Acceleration Y



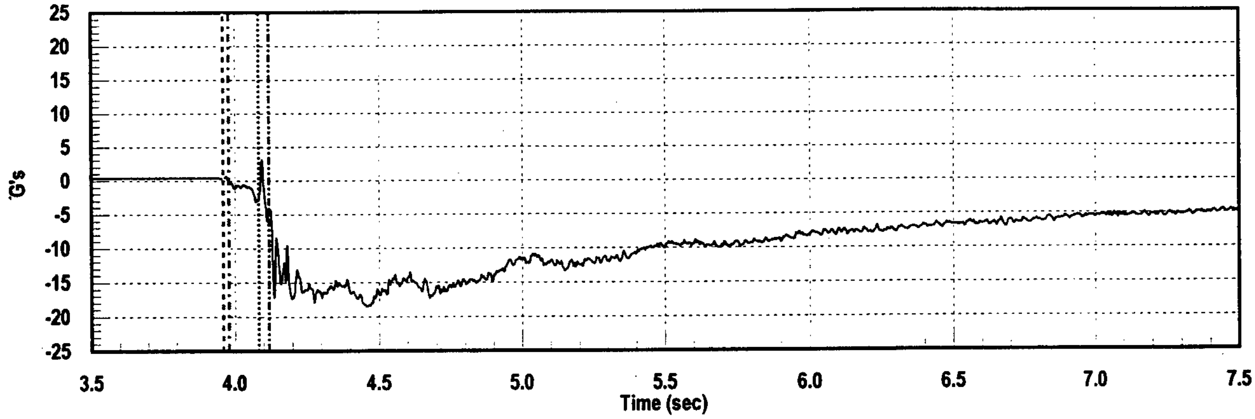
Chest Acceleration Z



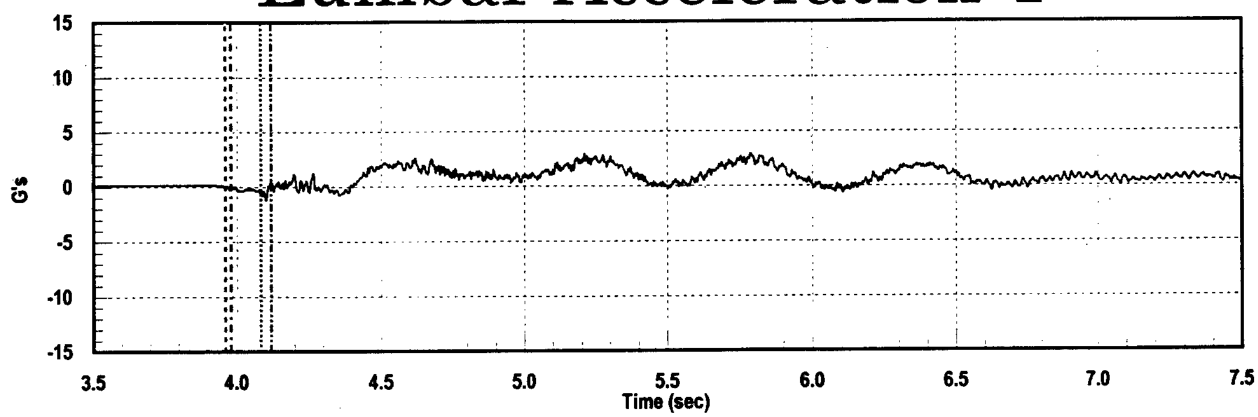
A-7

FL103012, 510 KEAS, 46,000 Ft

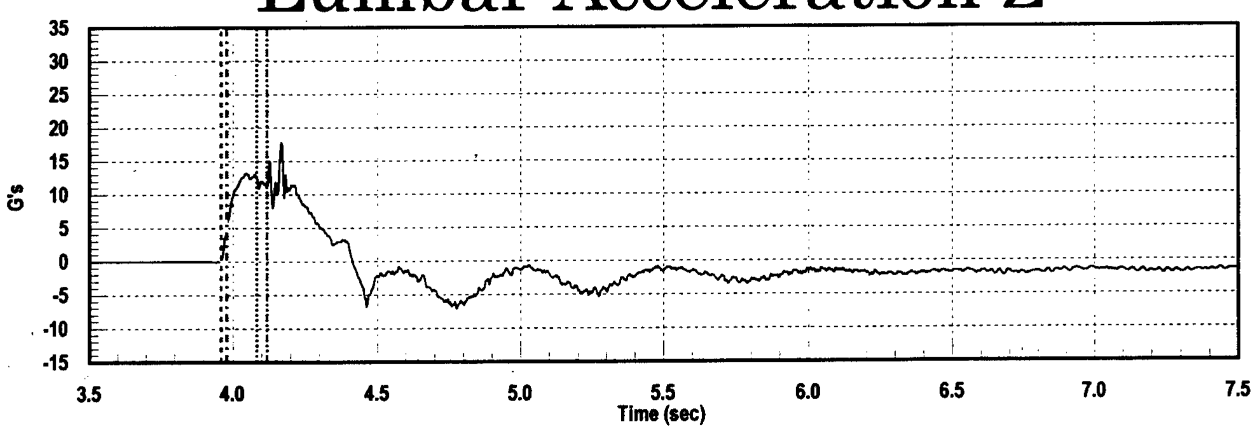
Lumbar Acceleration X



Lumbar Acceleration Y



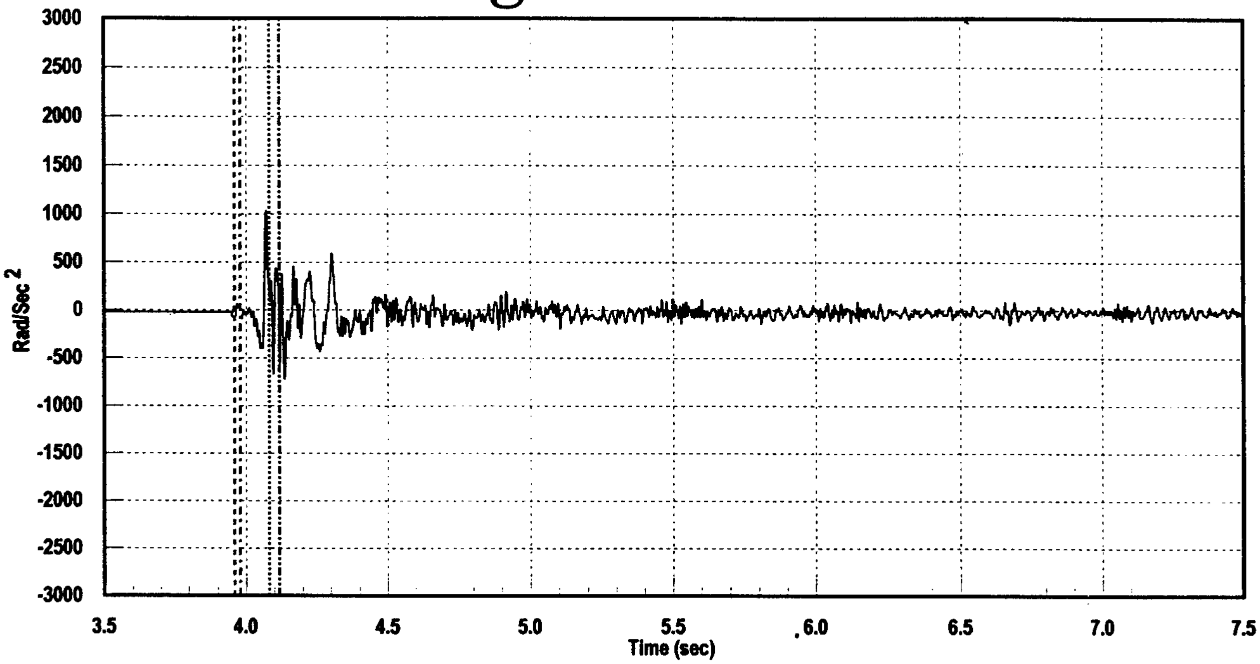
Lumbar Acceleration Z



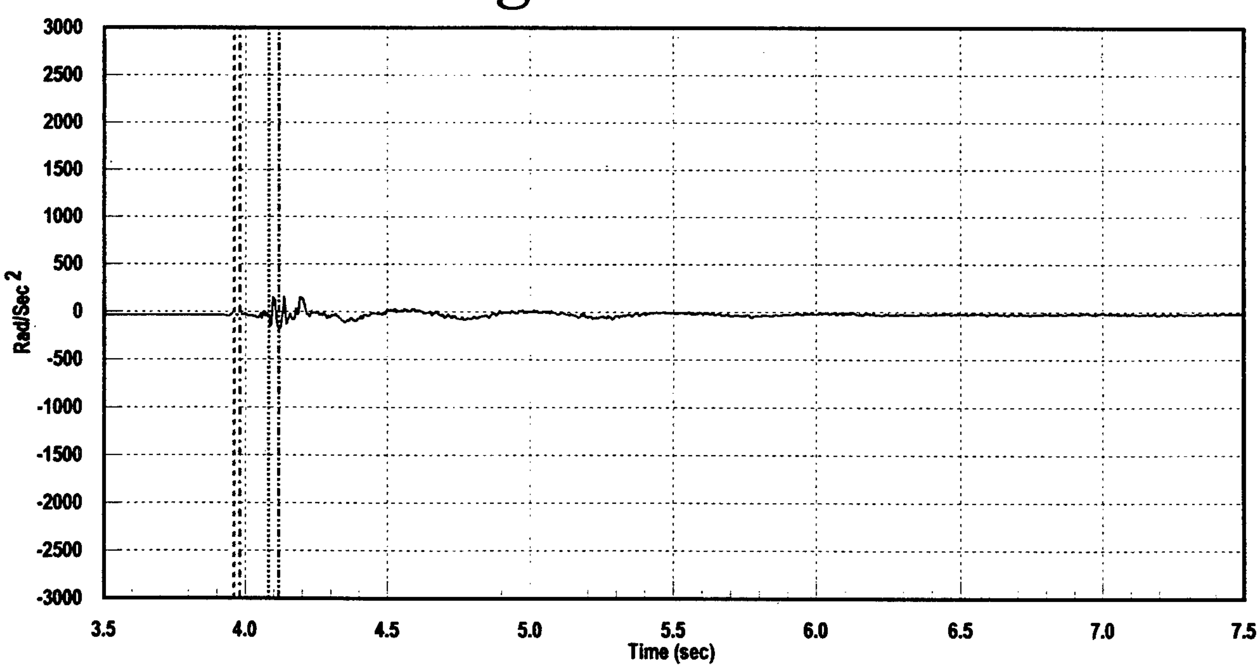
A-8

FL103012, 510 KEAS, 46,000 Ft

Head Angular Acceleration Y



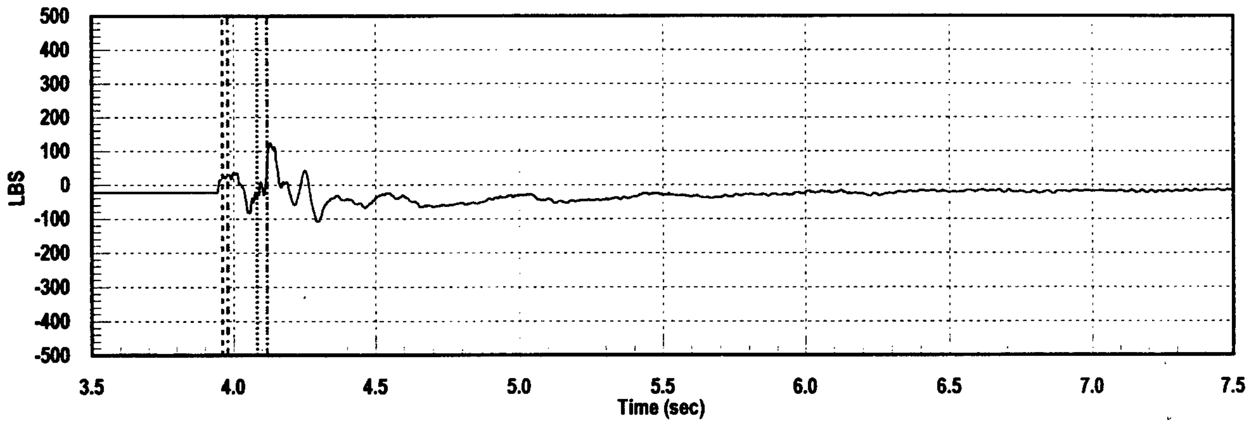
Chest Angular Acceleration Y



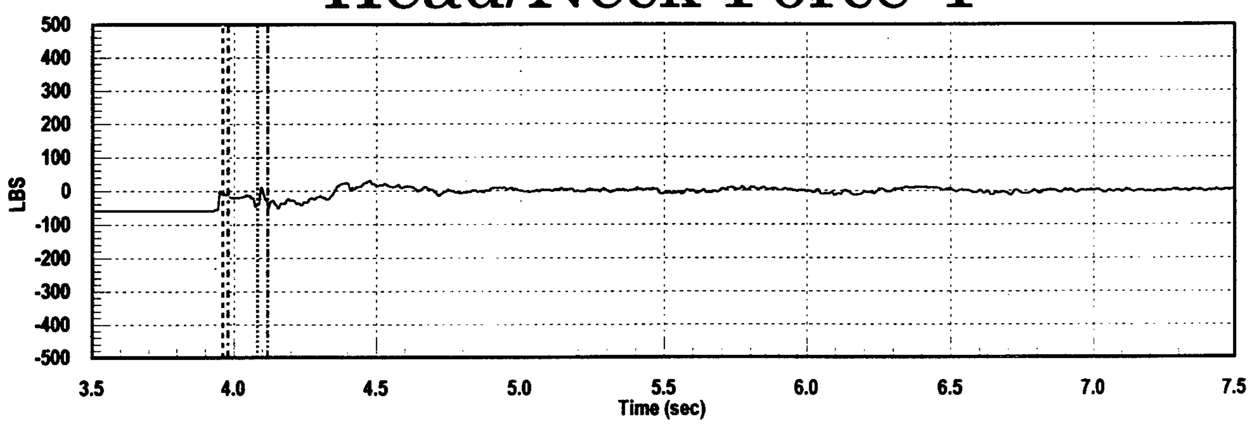
A-9

FL103012, 510 KEAS, 46,000 Ft

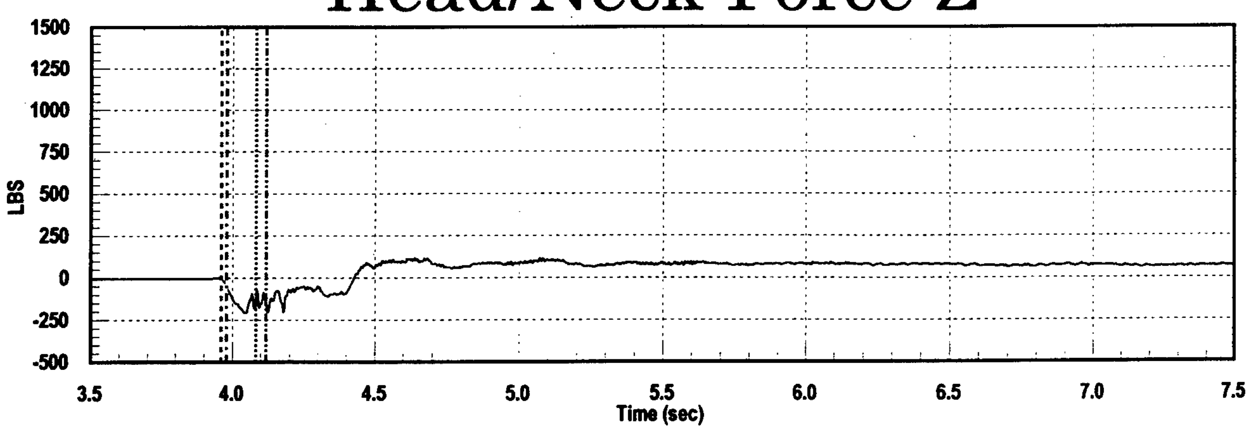
Head/Neck Force X



Head/Neck Force Y



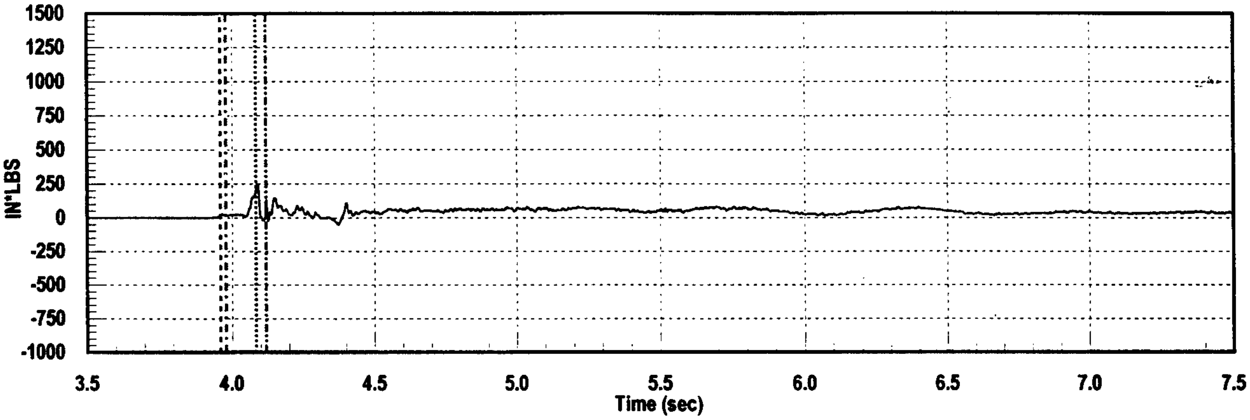
Head/Neck Force Z



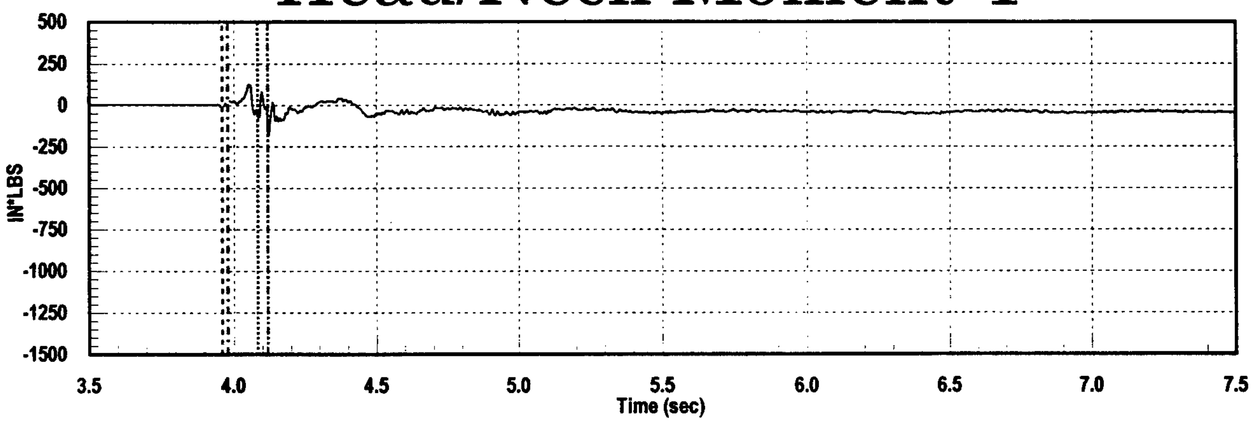
A-10

FL103012, 510 KEAS, 46,000 Ft

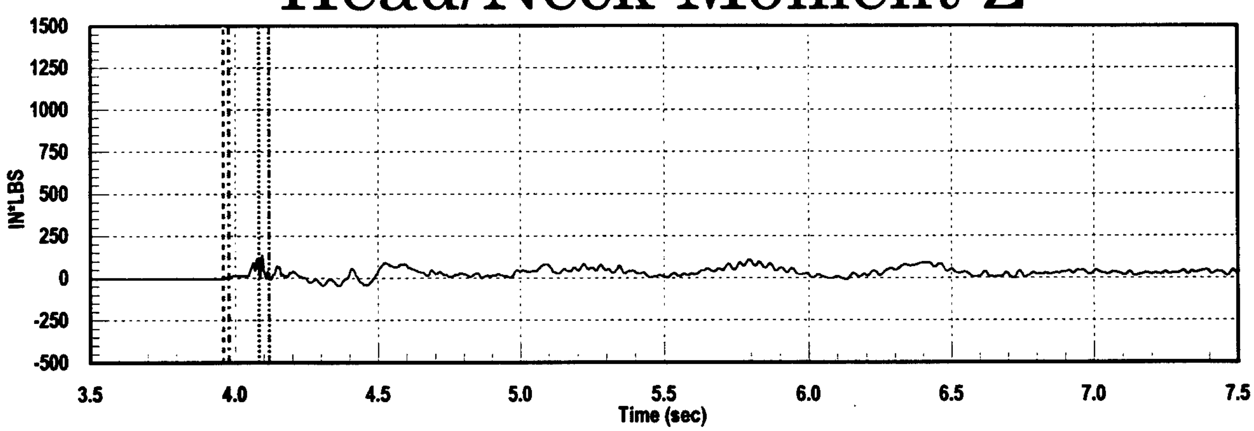
Head/Neck Moment X



Head/Neck Moment Y



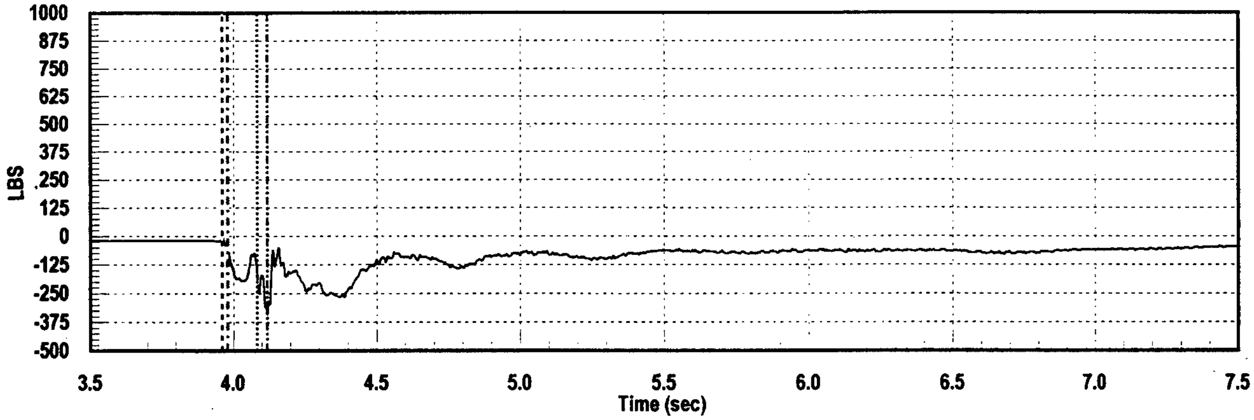
Head/Neck Moment Z



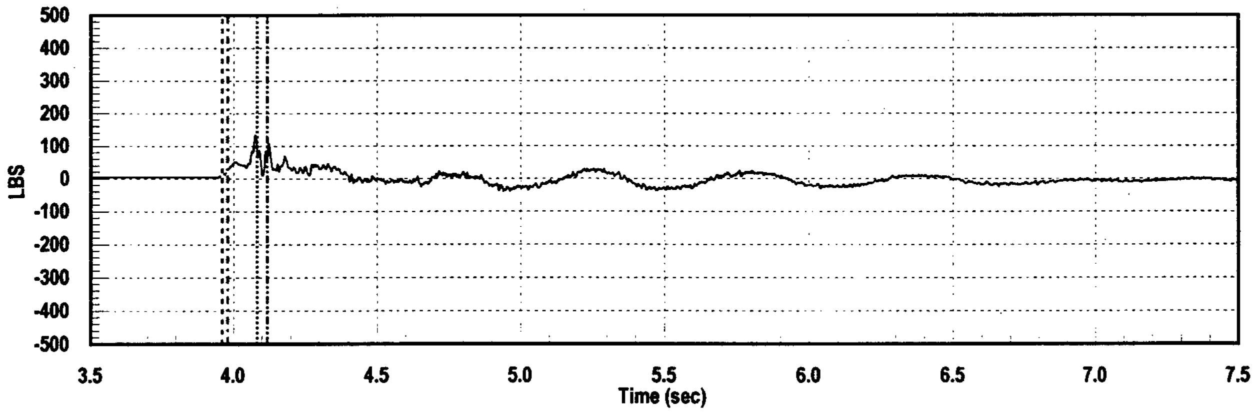
A-11

FL103012, 510 KEAS, 46,000 Ft

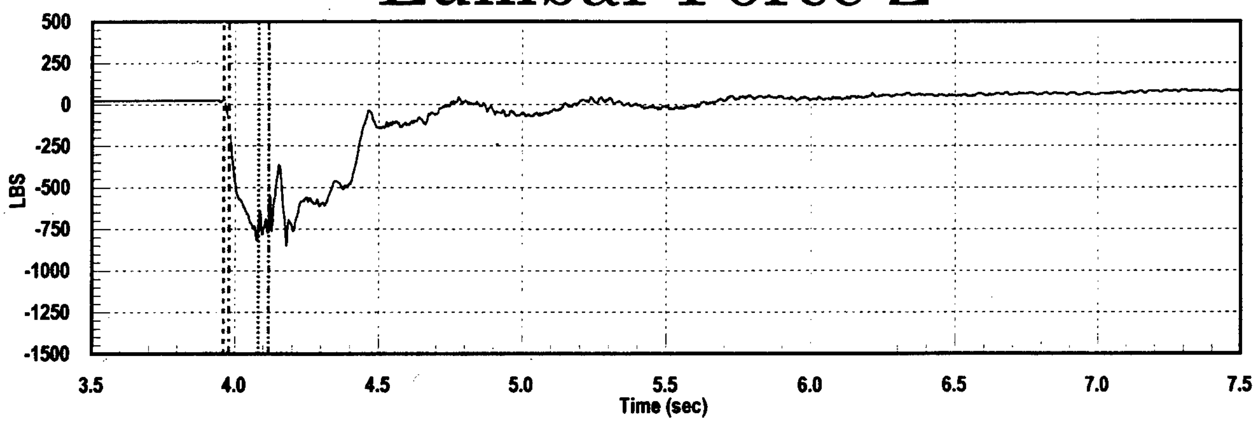
Lumbar Force X



Lumbar Force Y

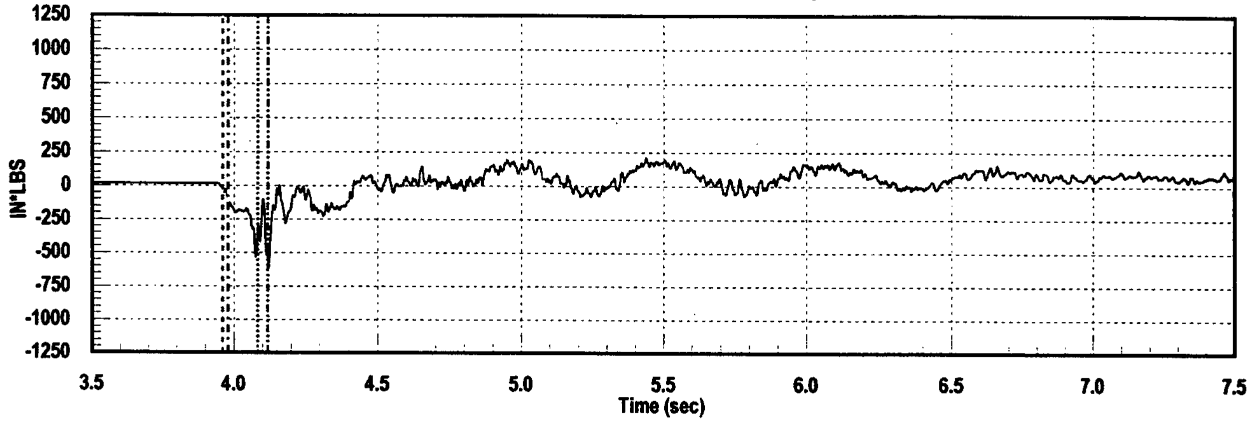


Lumbar Force Z

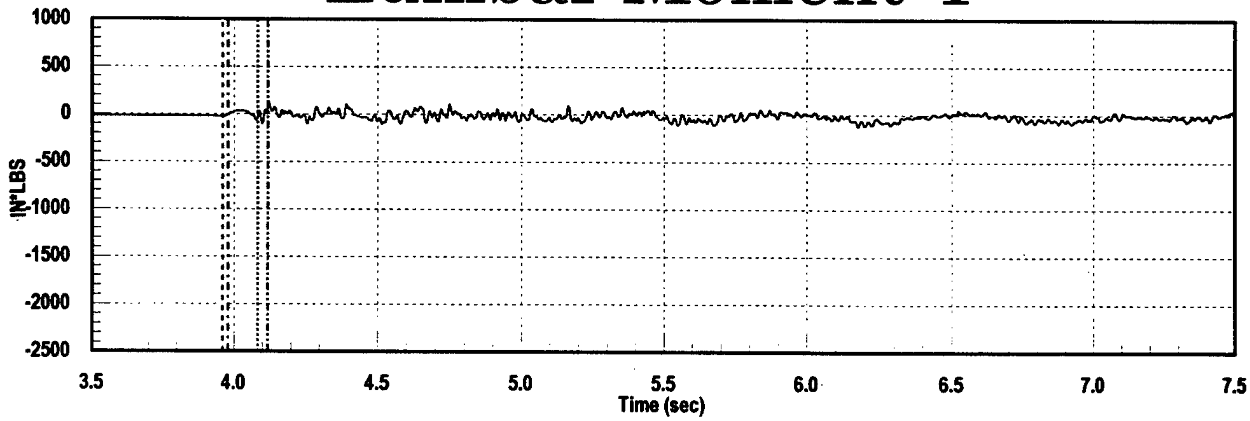


FL103012, 510 KEAS, 46,000 Ft

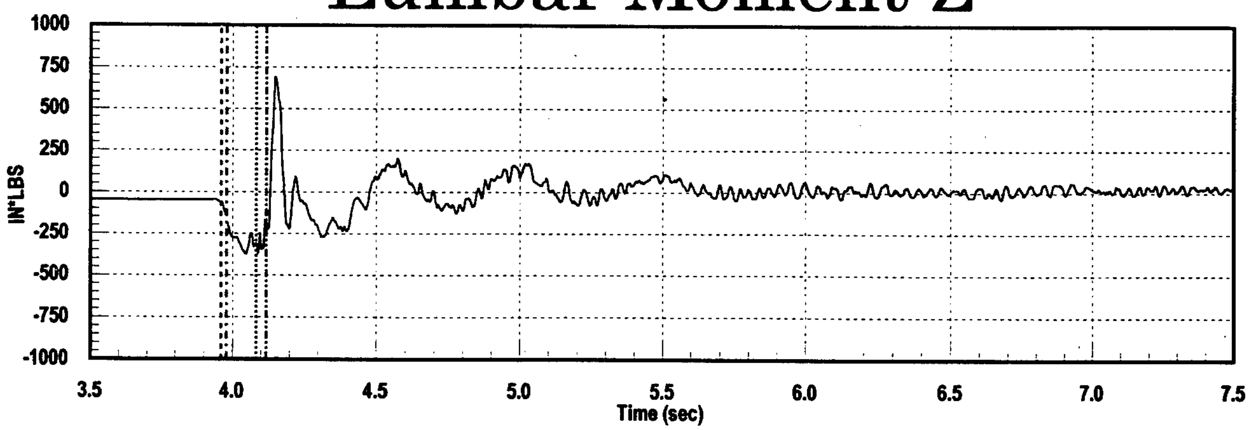
Lumbar Moment X



Lumbar Moment Y



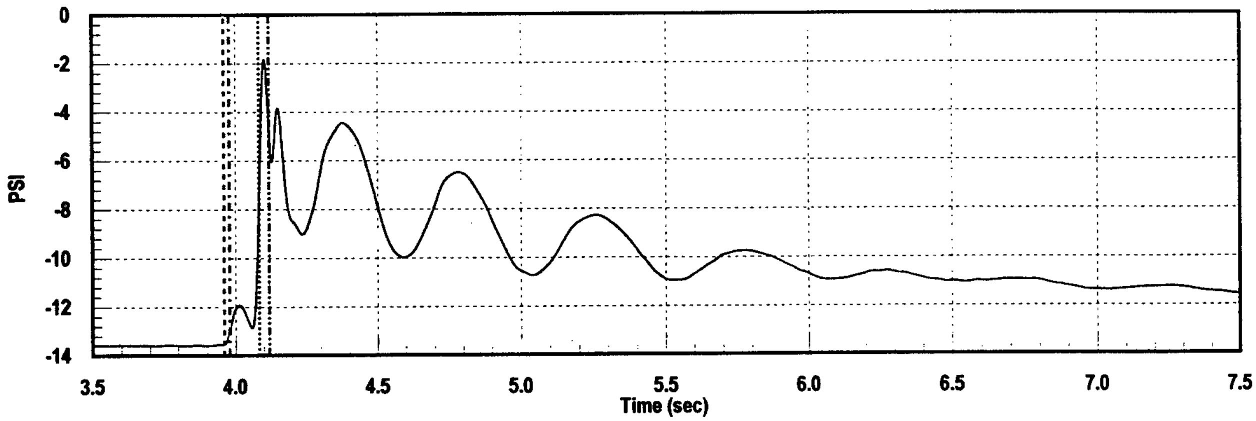
Lumbar Moment Z



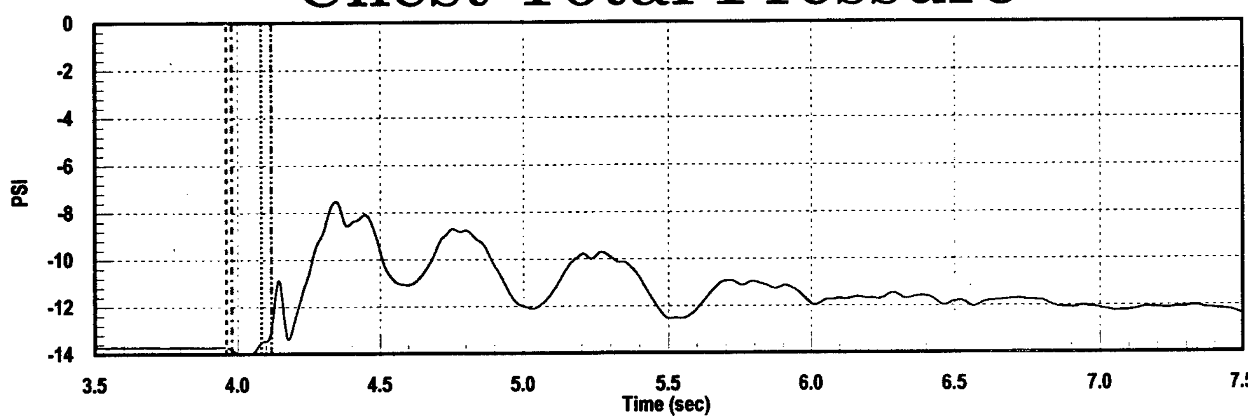
A-13

FL103012, 510 KEAS, 46,000 Ft

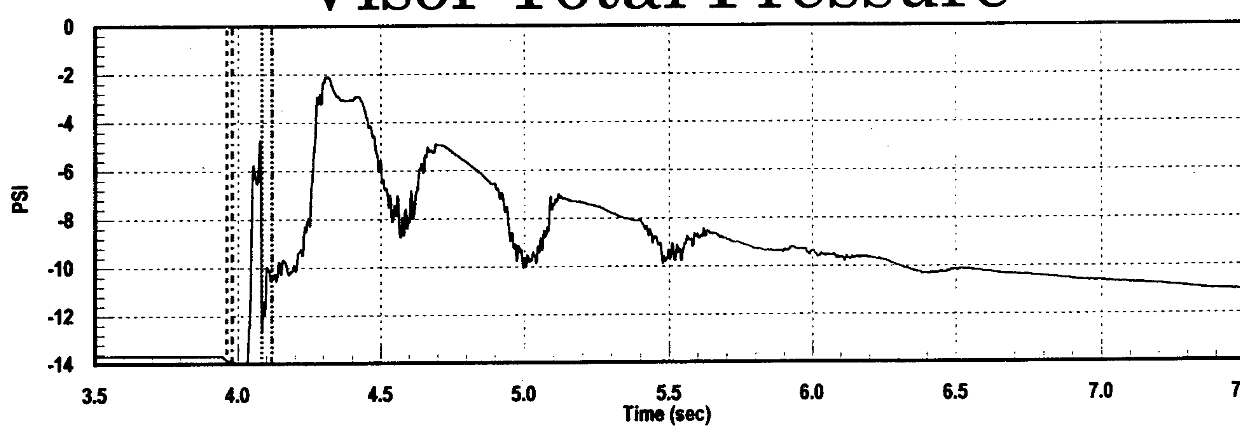
Windblast Deflector Total Pressure



Chest Total Pressure



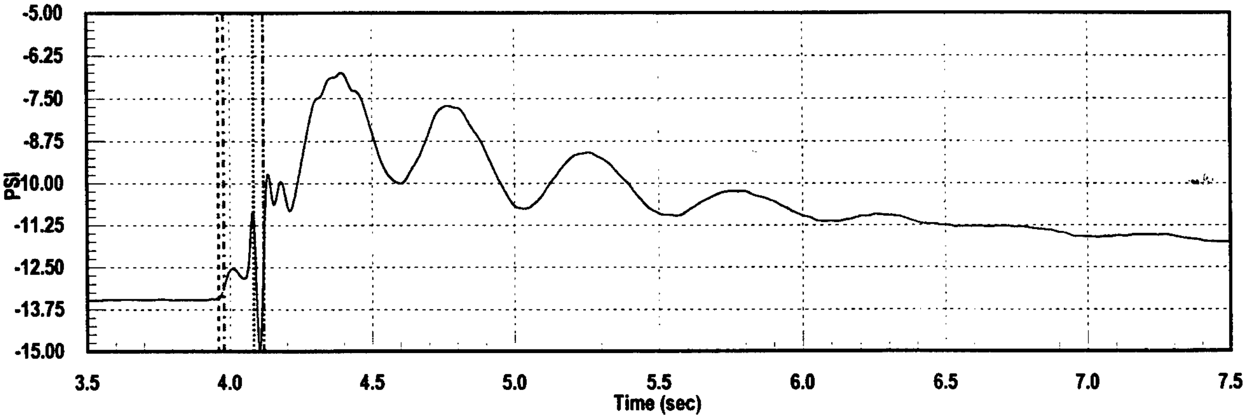
Visor Total Pressure



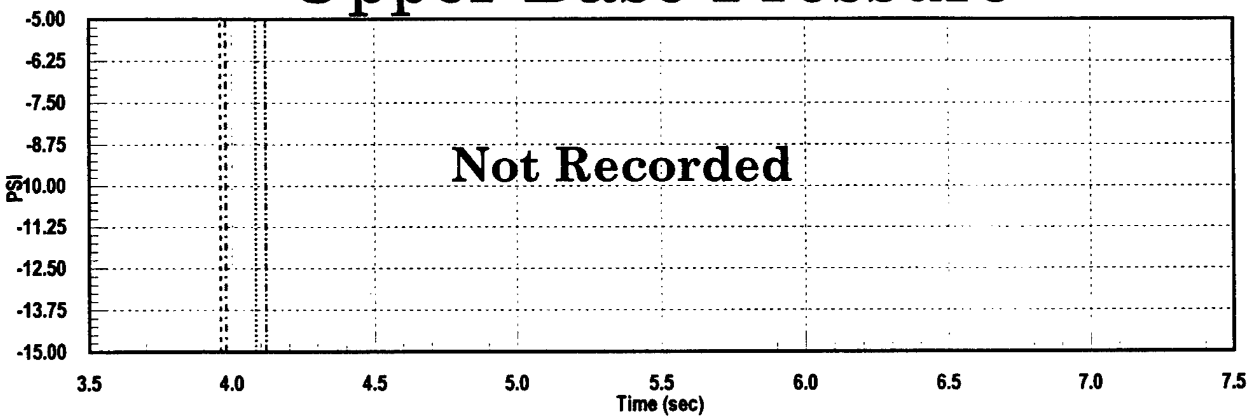
A-14

FL103012, 510 KEAS, 46,000 Ft

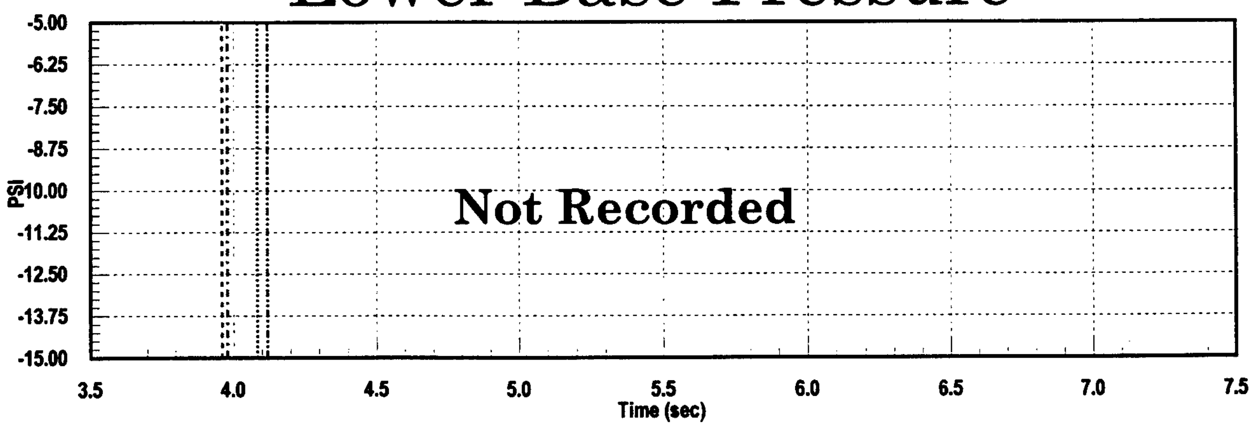
Windblast Deflector Static Pressure



Upper Base Pressure



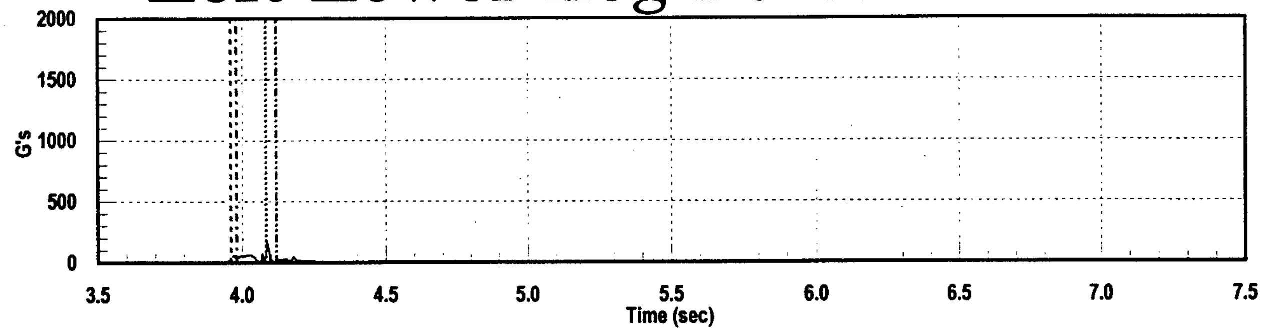
Lower Base Pressure



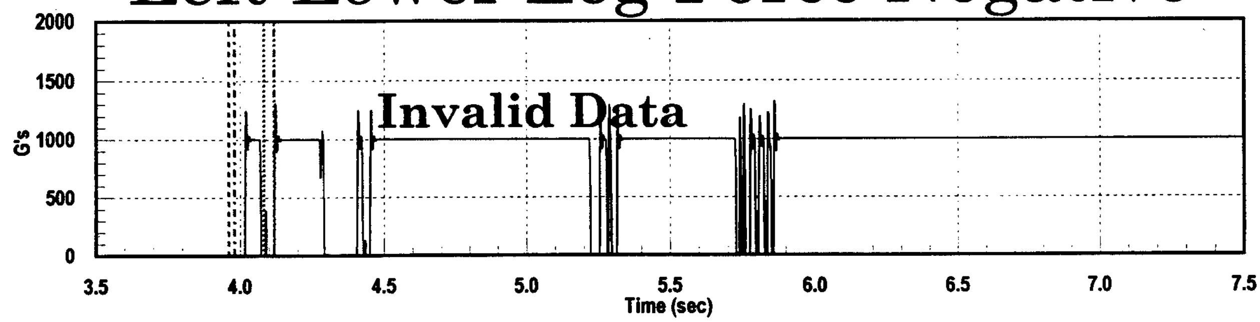
A-15

FL103012, 510 KEAS, 46,000 Ft

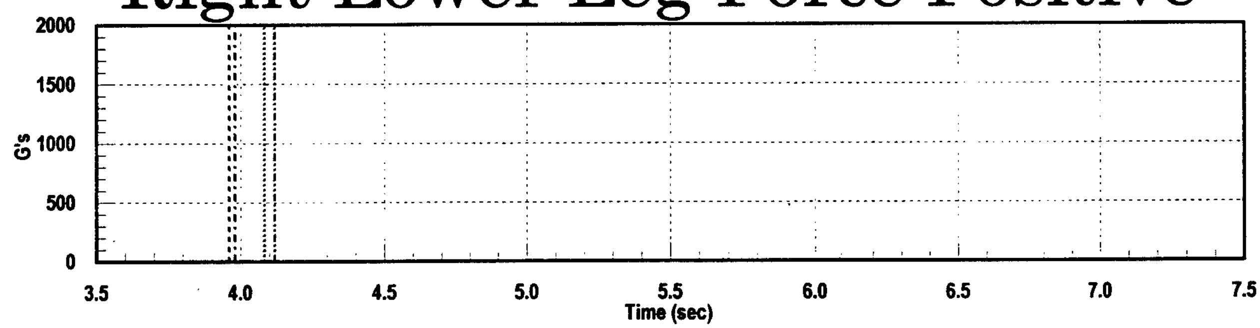
Left Lower Leg Force Positive



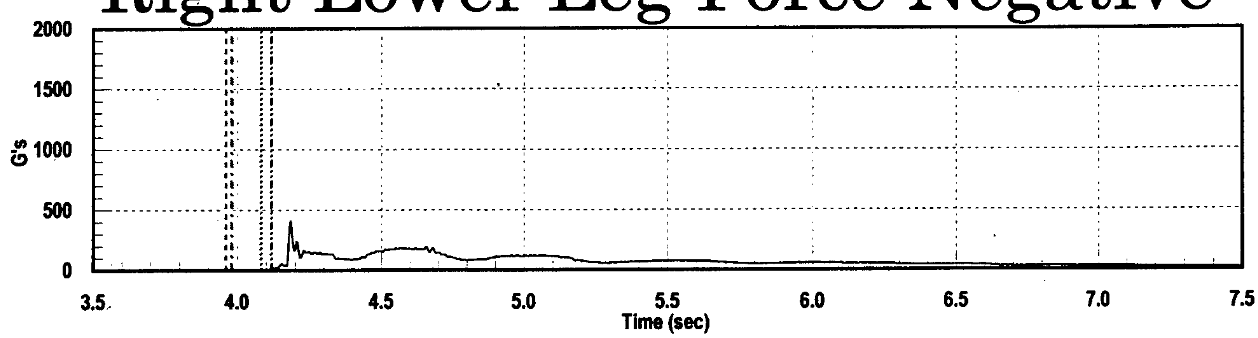
Left Lower Leg Force Negative



Right Lower Leg Force Positive

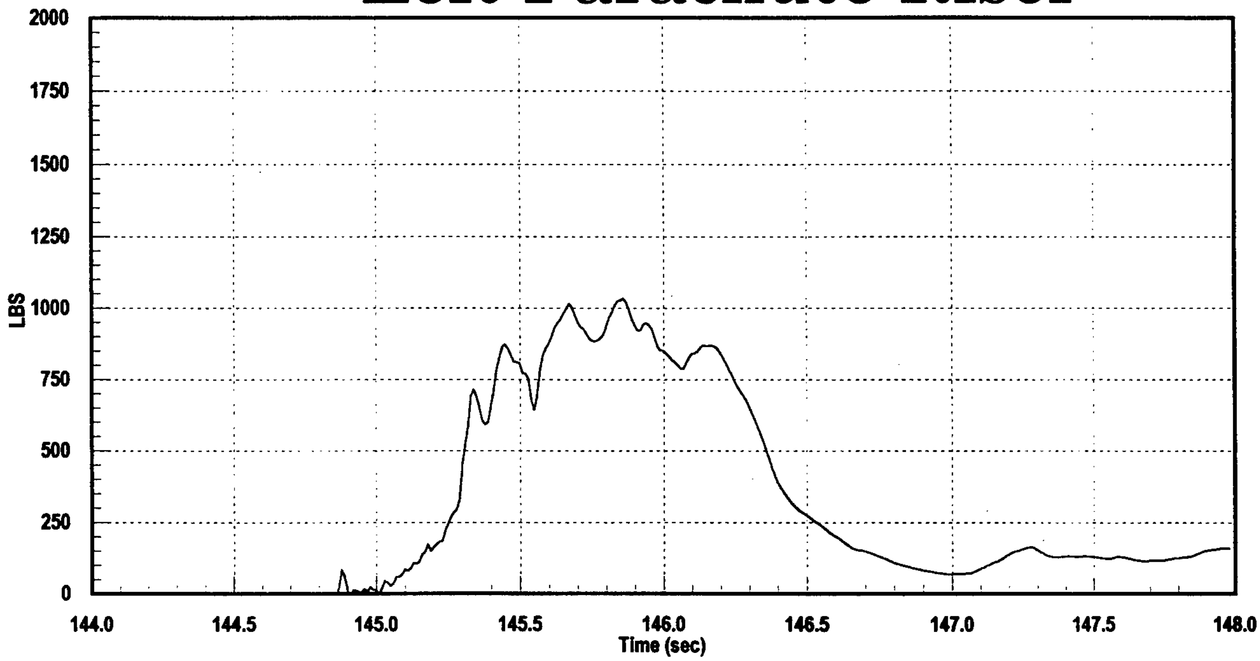


Right Lower Leg Force Negative

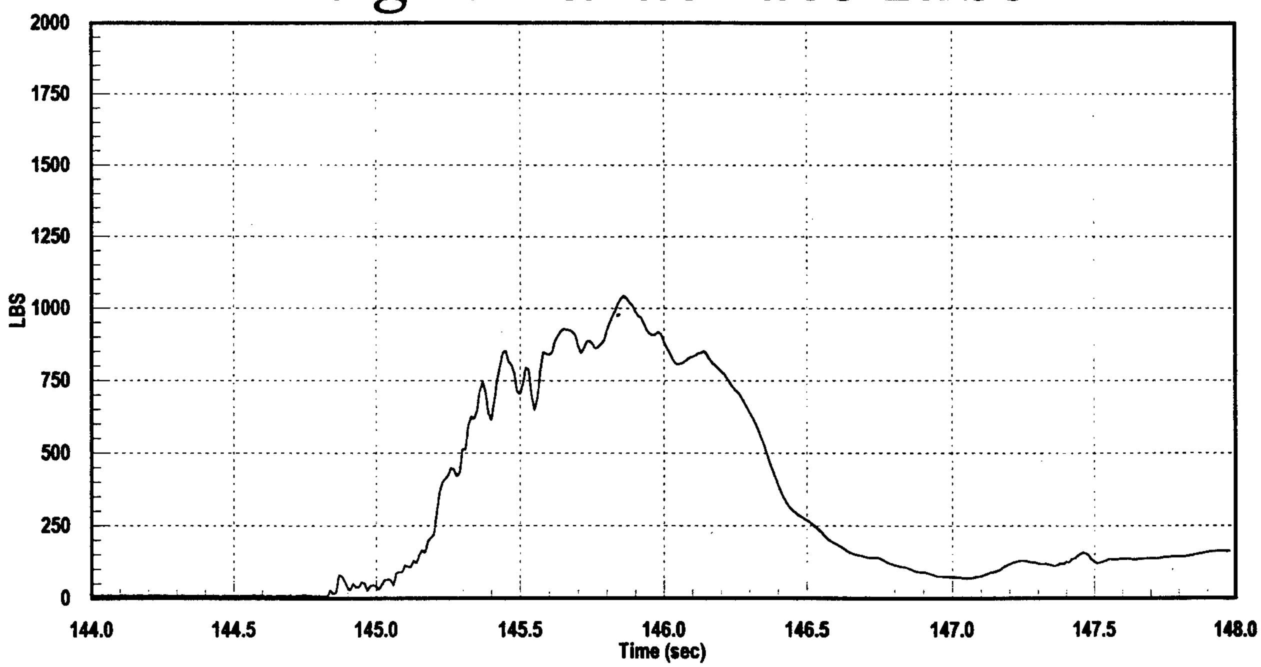


FL103012, 510 KEAS, 46,000 Ft

Left Parachute Riser

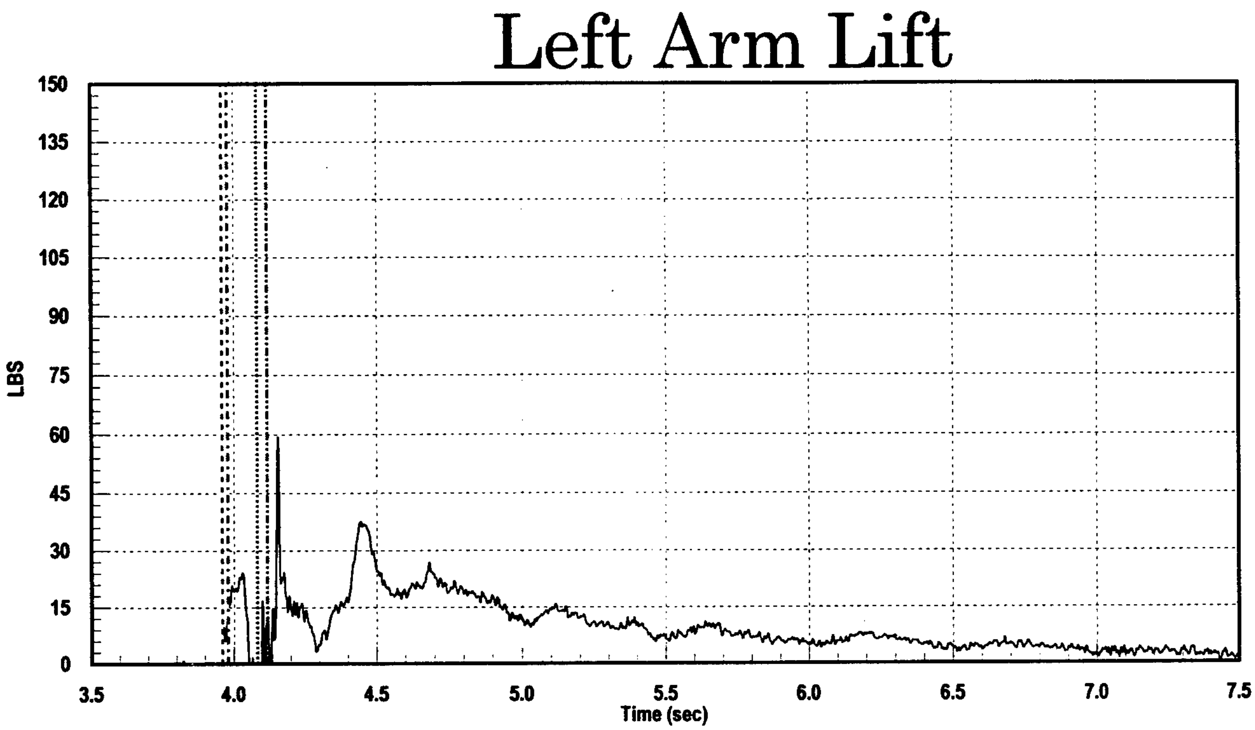


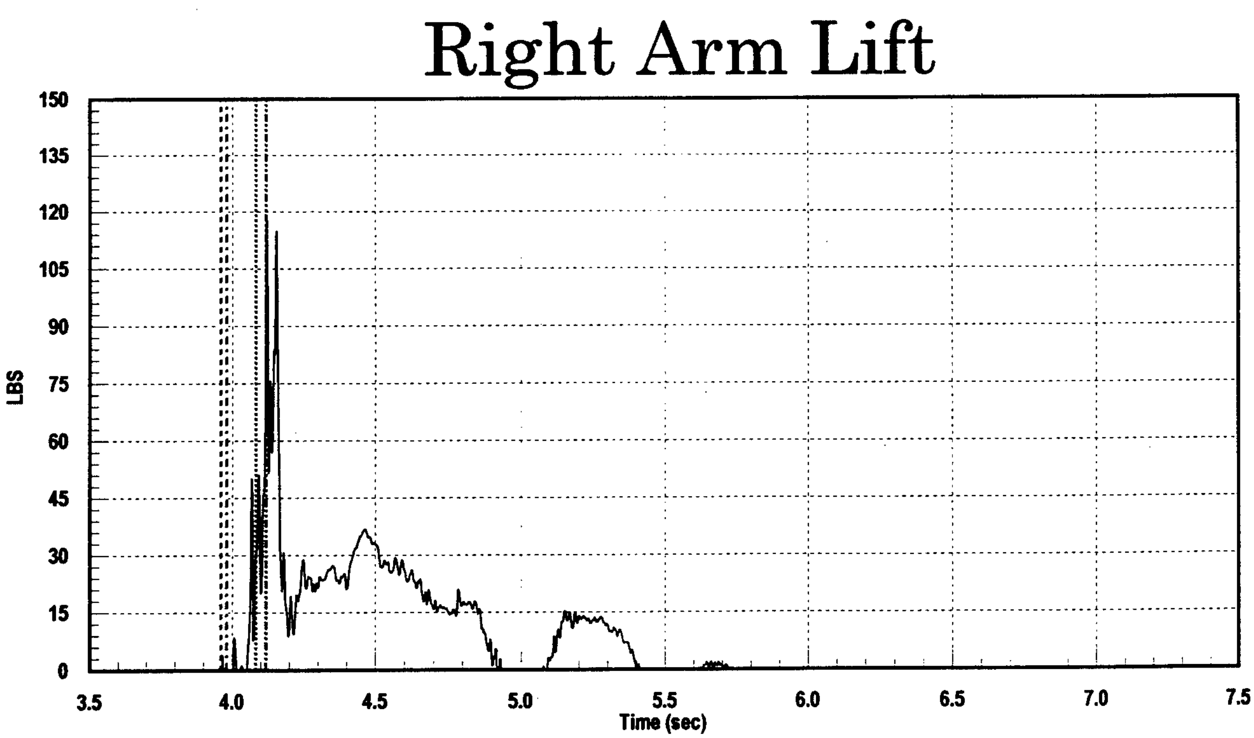
Right Parachute Riser



A-17

FL103012, 510 KEAS, 46,000 Ft

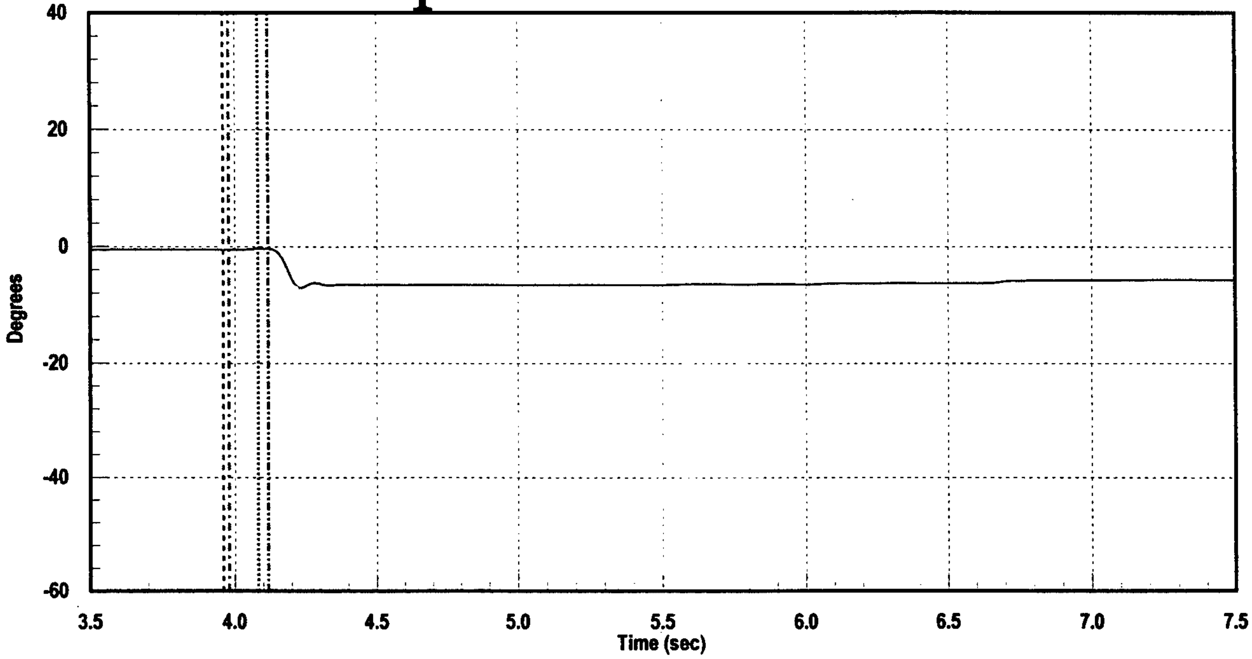




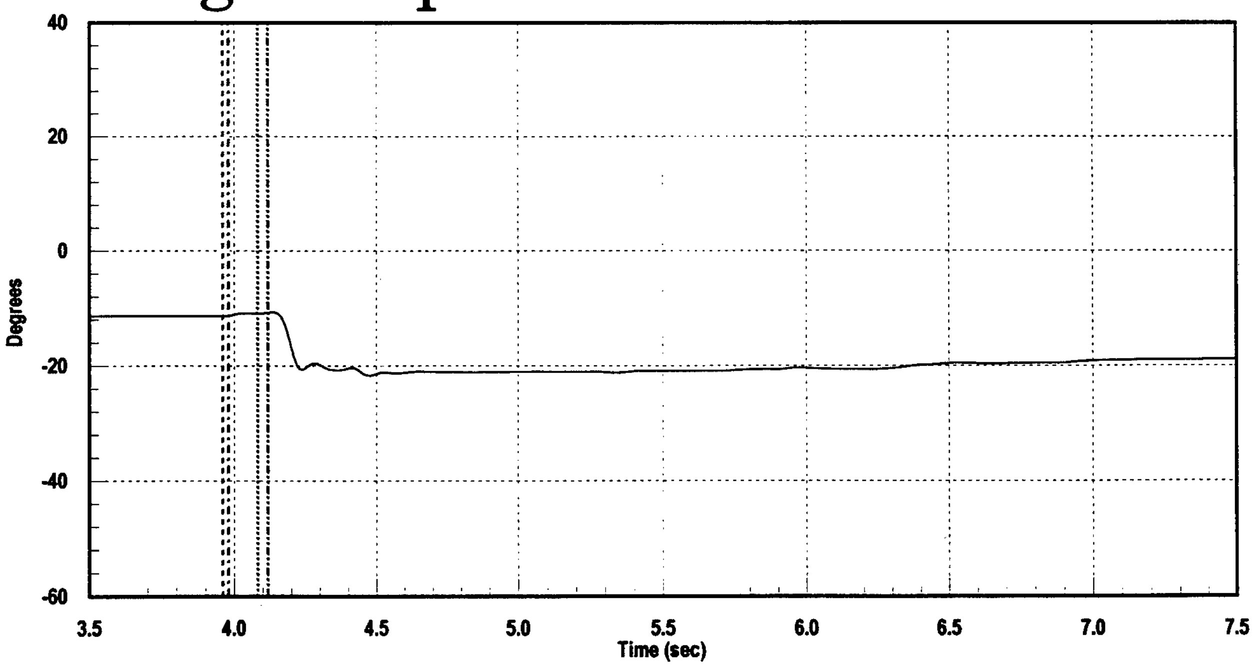
A-18

FL103012, 510 KEAS, 46,000 Ft

Left Hip Abduction/Adduction

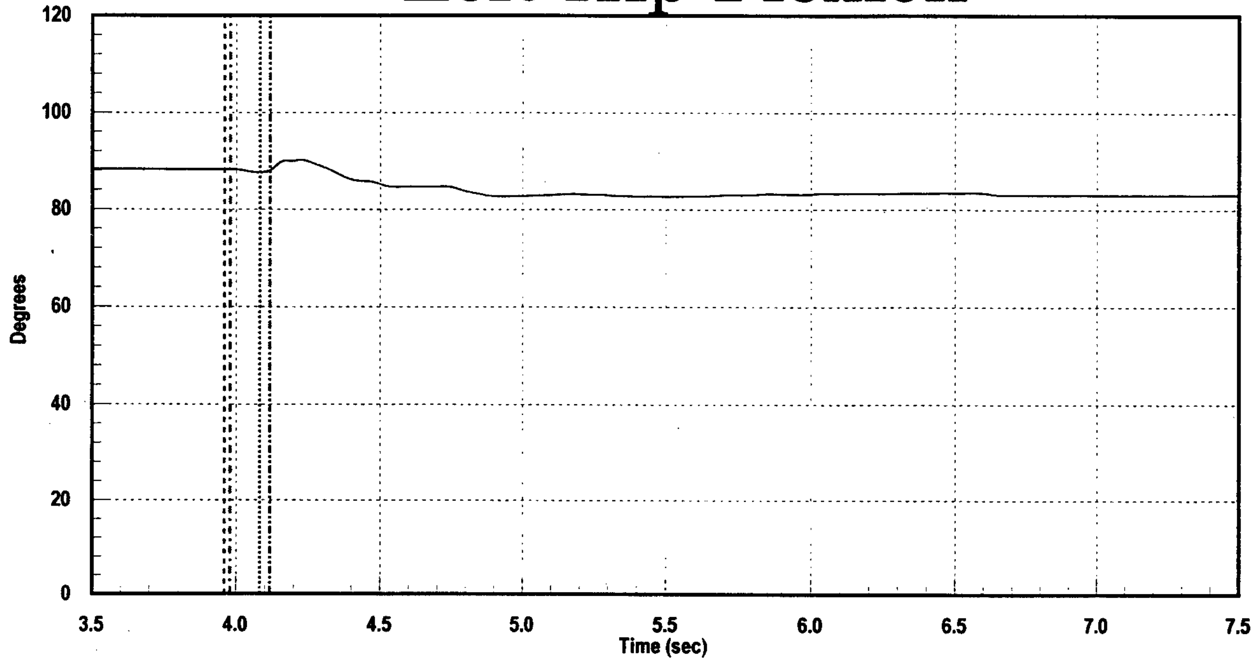


Right Hip Abduction/Adduction

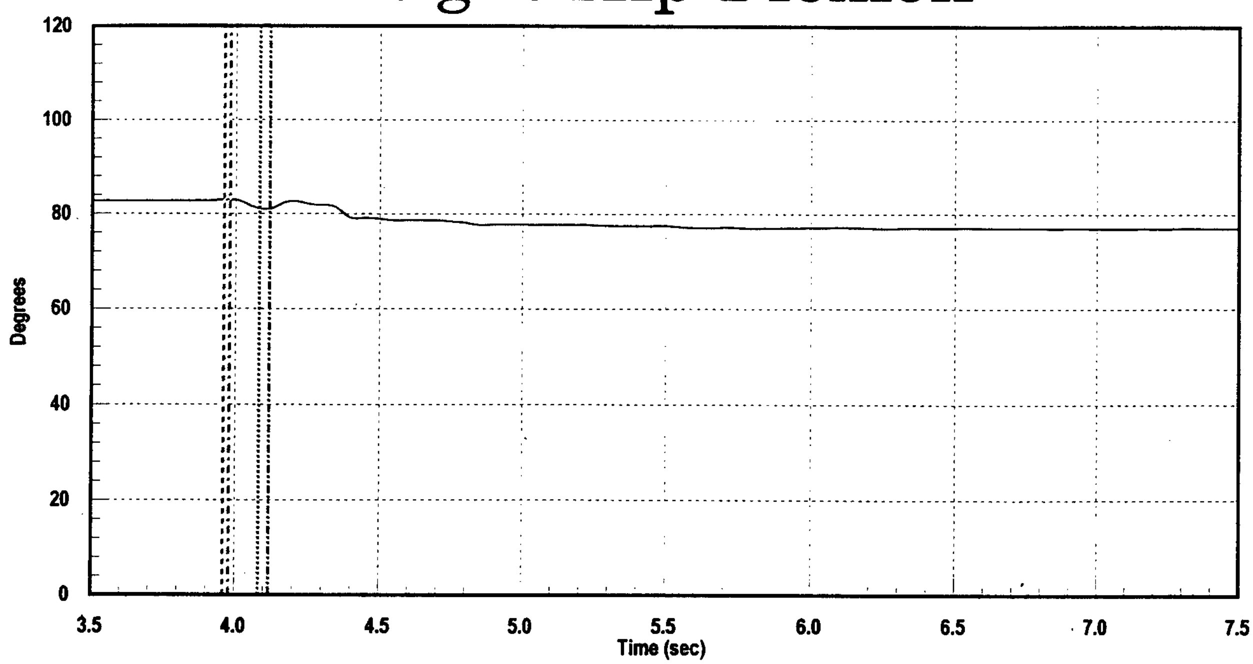


FL103012, 510 KEAS, 46,000 Ft

Left Hip Flexion



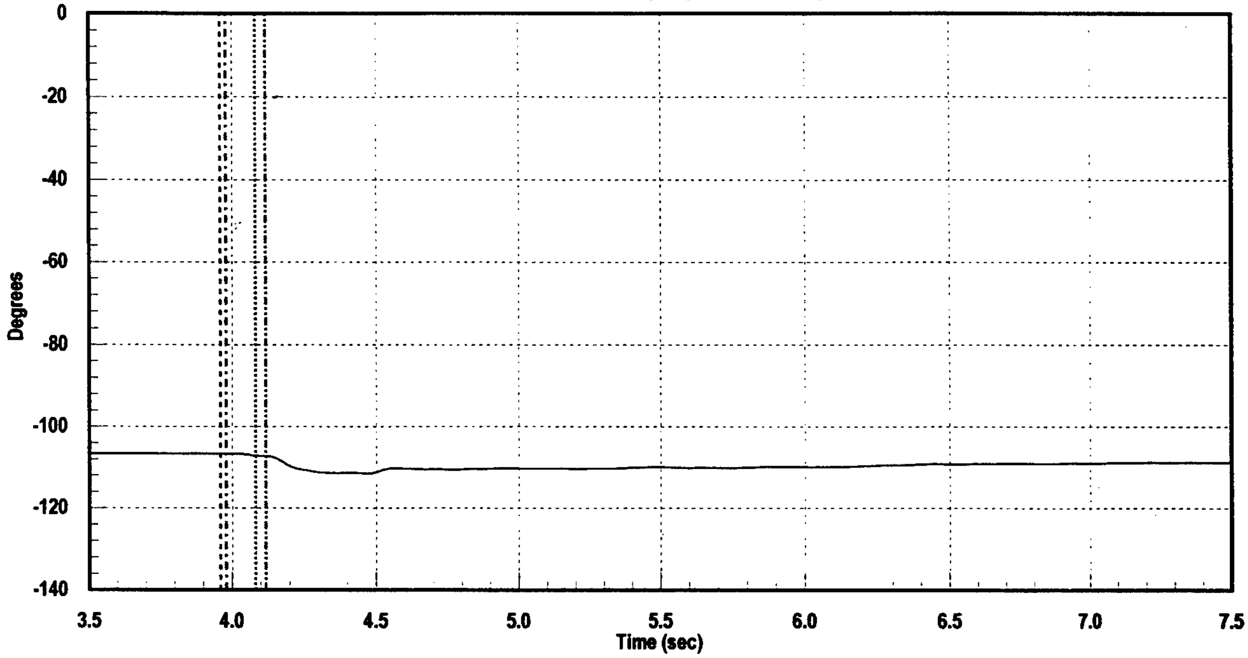
Right Hip Flexion



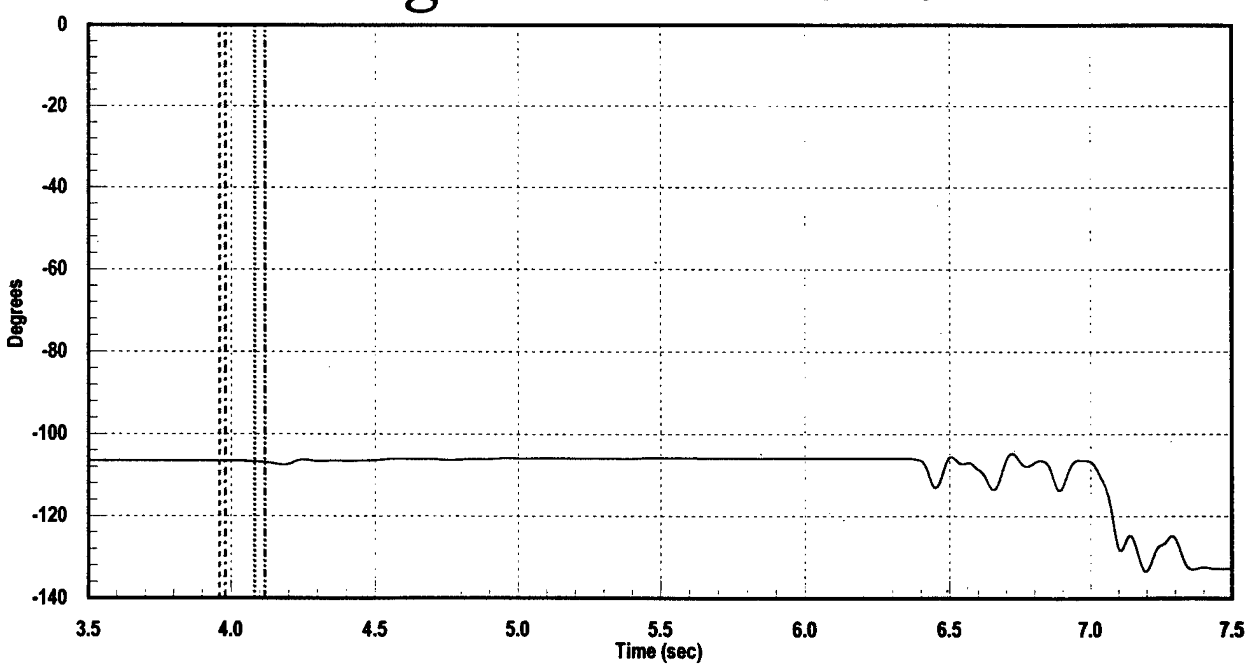
A-20

FL103012, 510 KEAS, 46,000 Ft

Left Knee Flexion



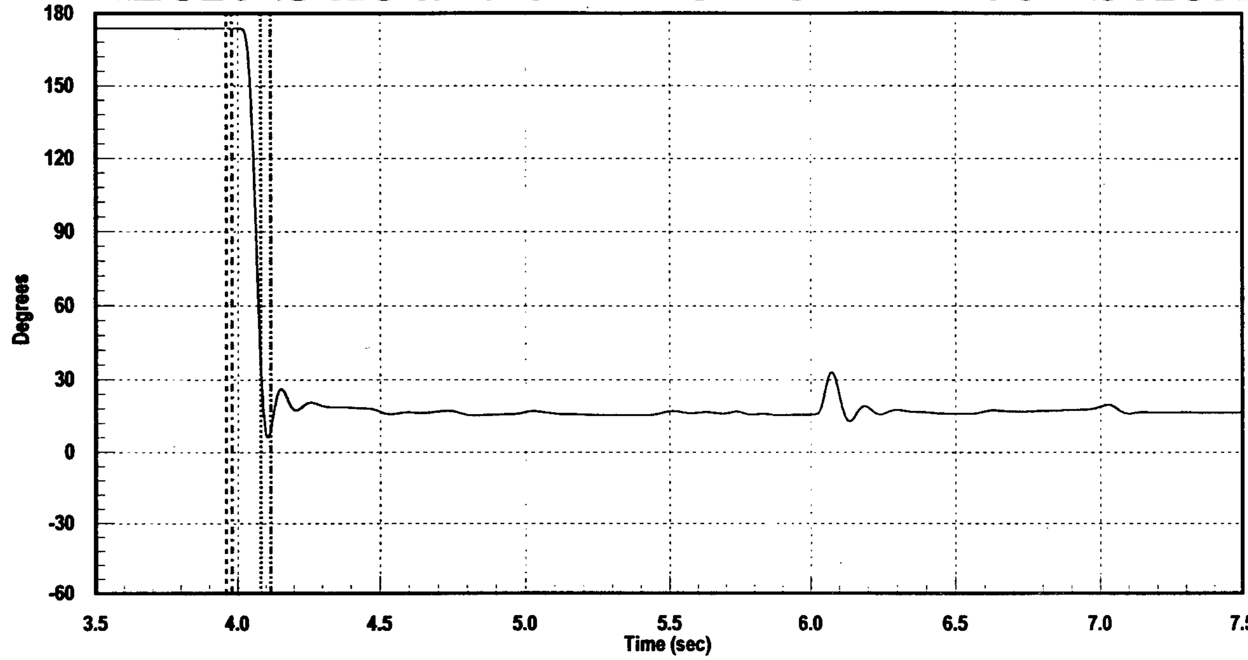
Right Knee Flexion



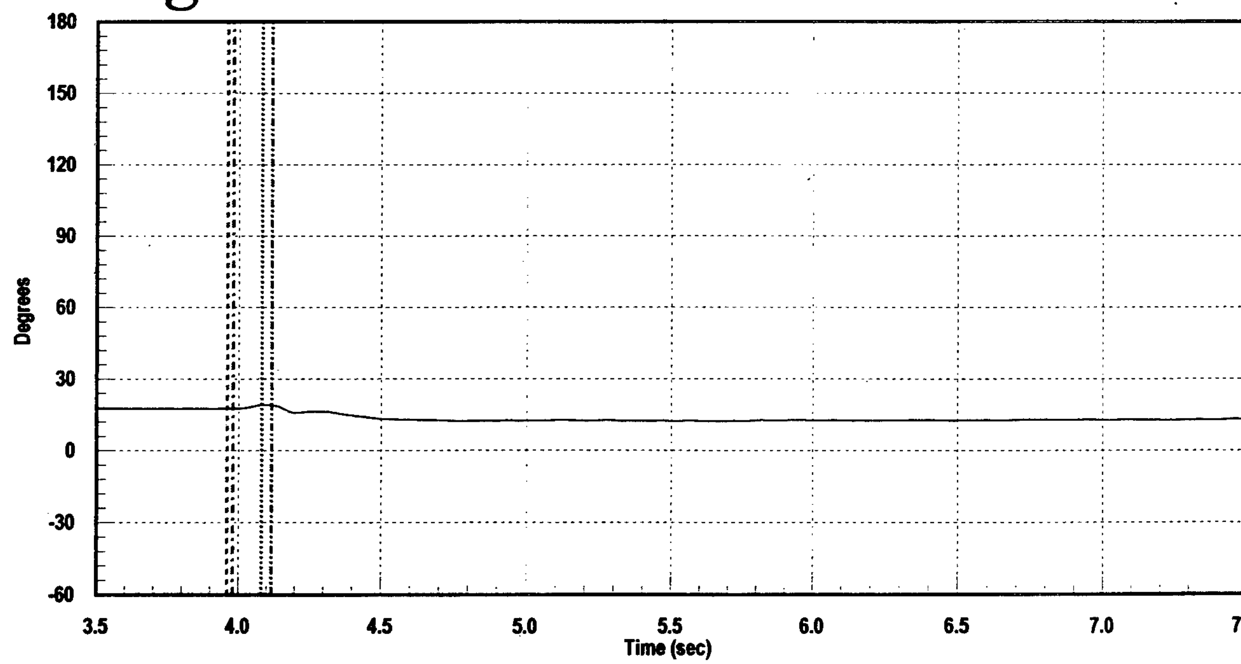
A-21

FL103012, 510 KEAS, 46,000 Ft

Left Shoulder Flexion/Extenstion

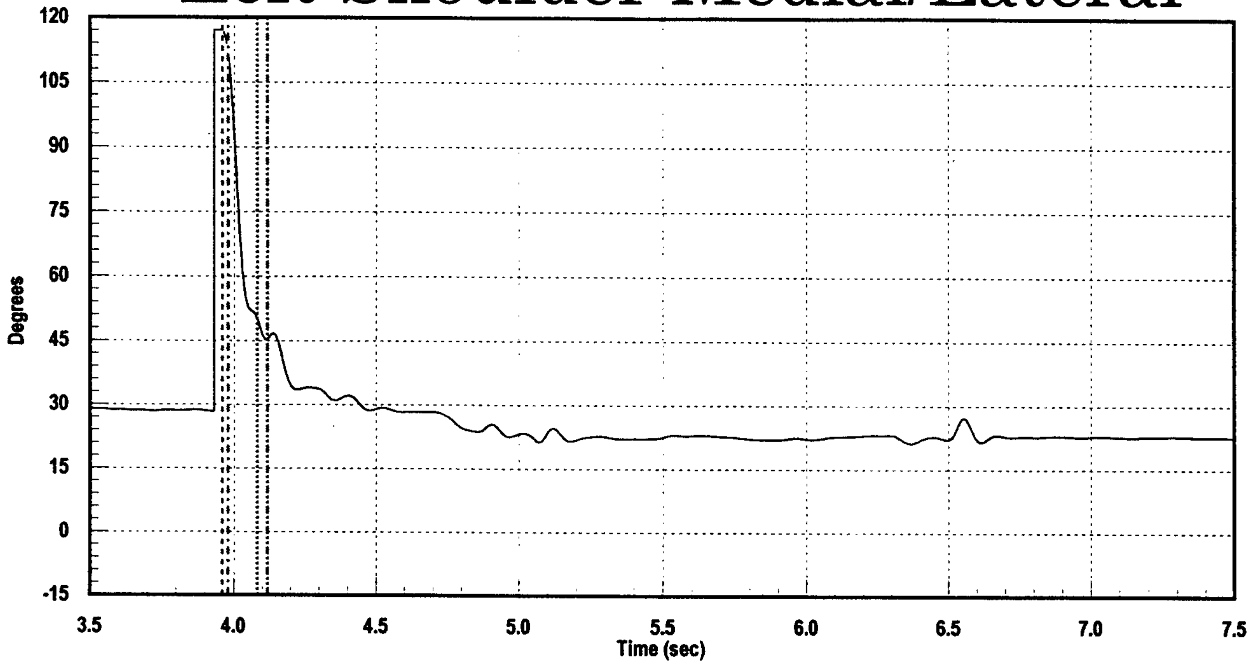


Right Shoulder Flexion/Extension

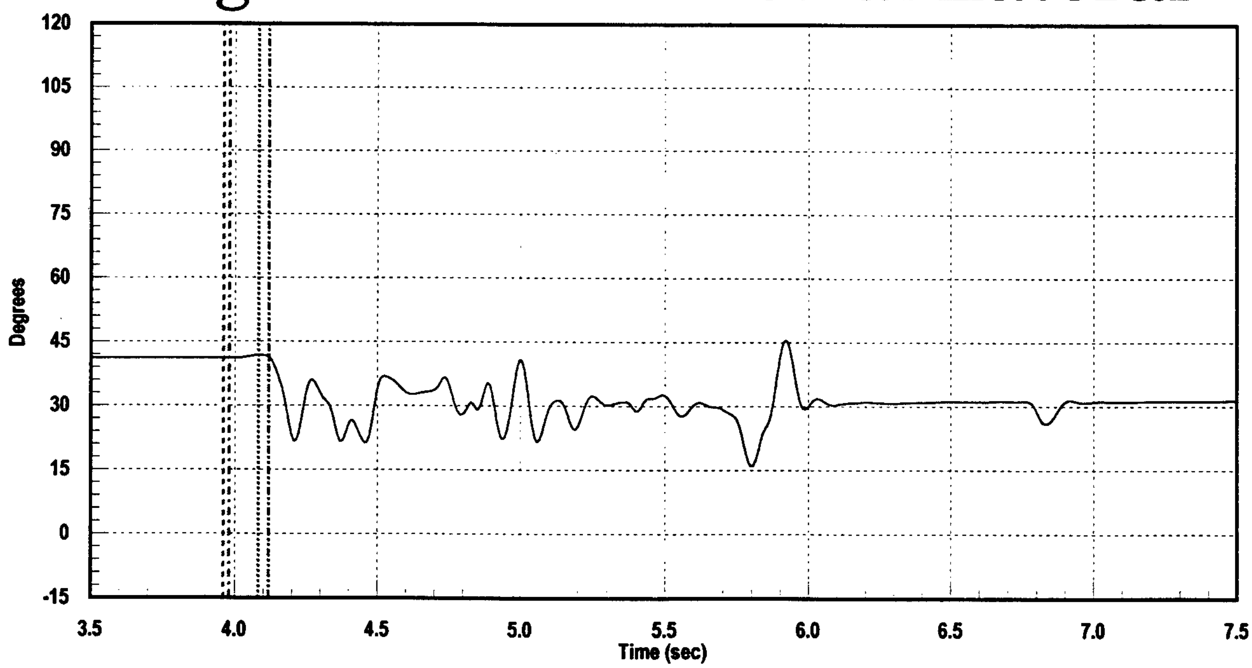


FL103012, 510 KEAS, 46,000 Ft

Left Shoulder Medial/Lateral



Right Shoulder Medial/Lateral

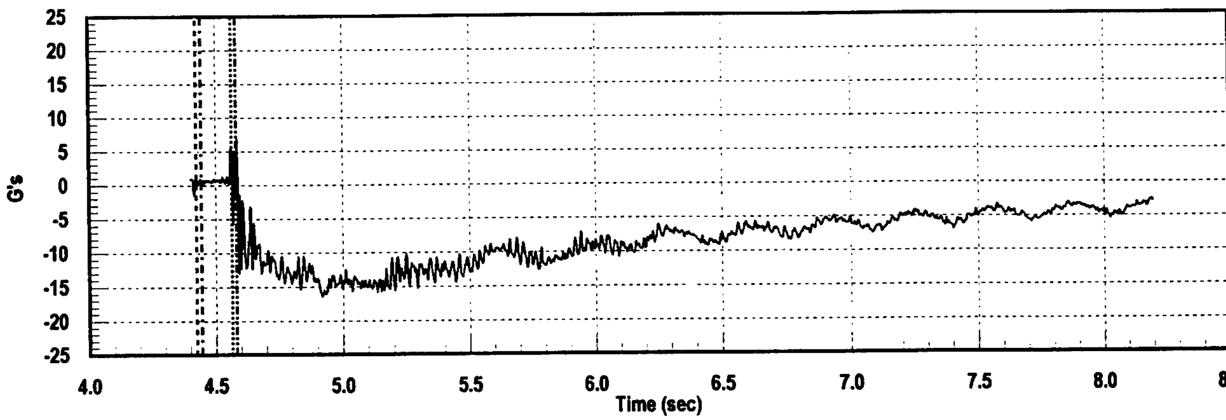


FL097516, 480 KEAS, 56,000 Ft
Processed Data

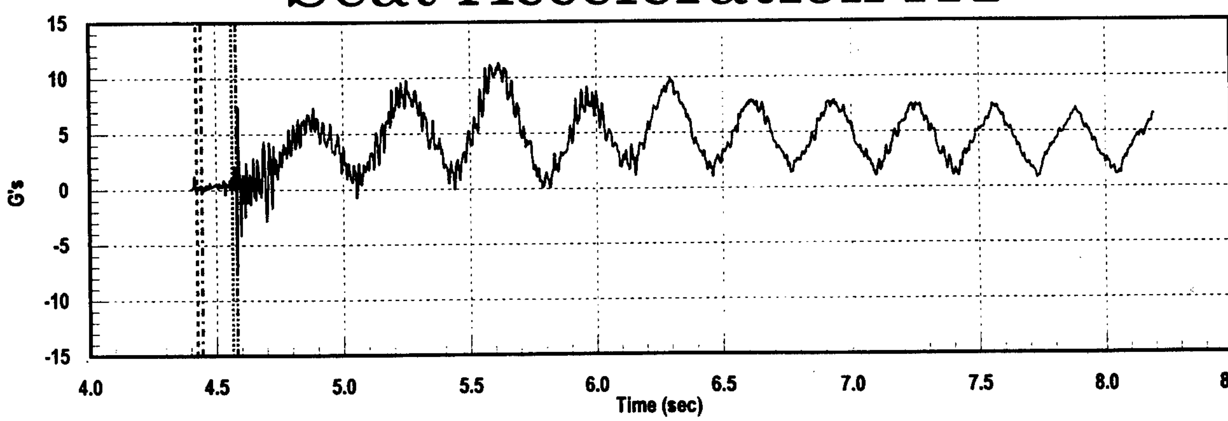
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL097516, 480 KEAS, 56,000 Ft

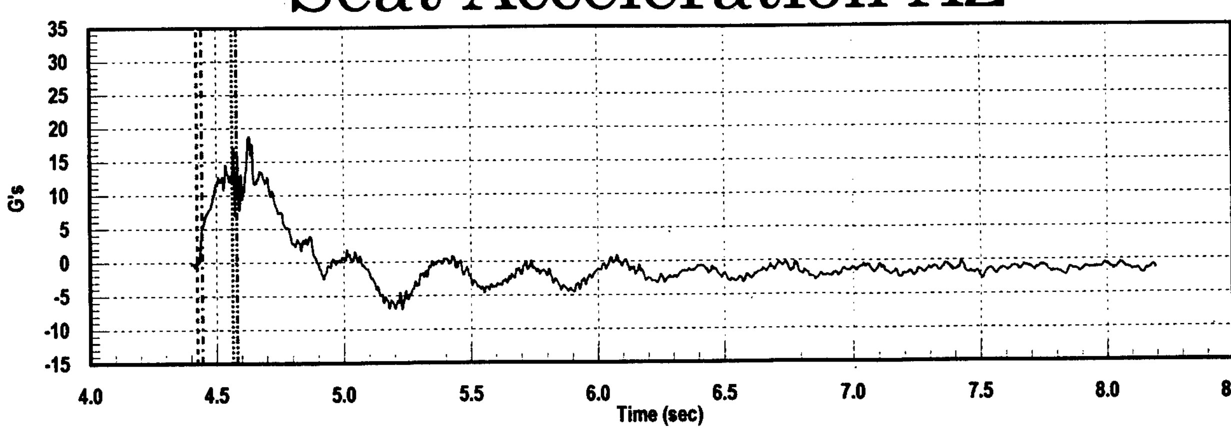
Seat Acceleration AX



Seat Acceleration AY



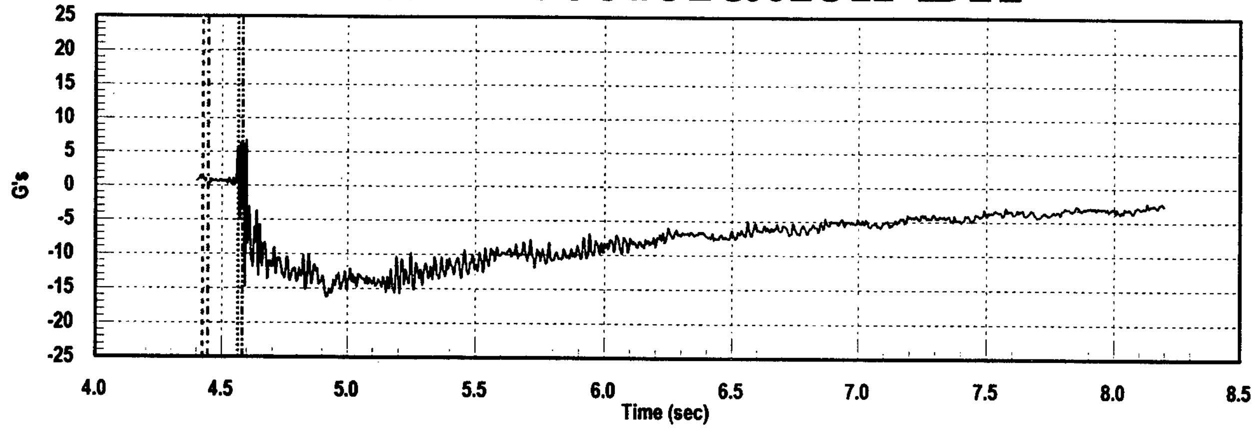
Seat Acceleration AZ



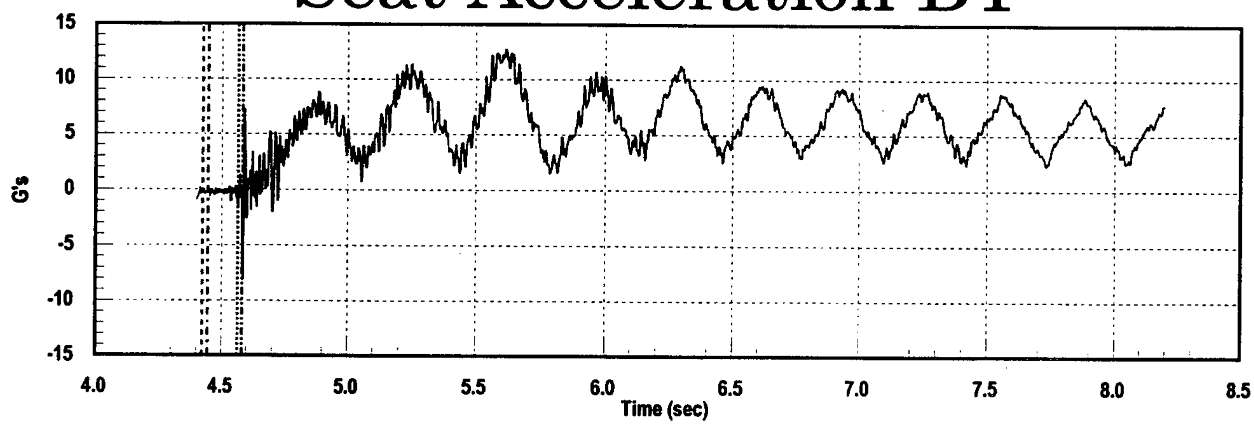
A-1

FL097516, 480 KEAS, 56,000 Ft

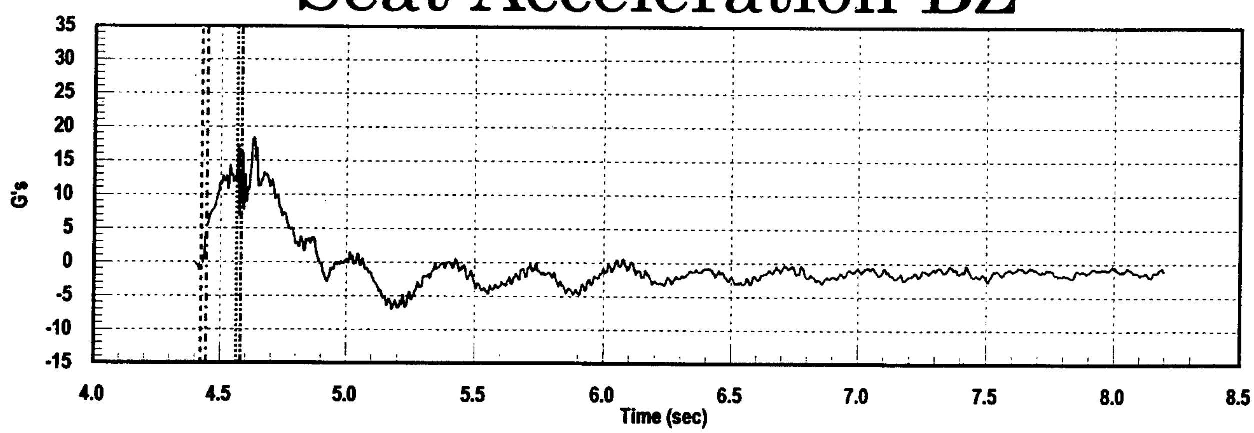
Seat Acceleration BX



Seat Acceleration BY



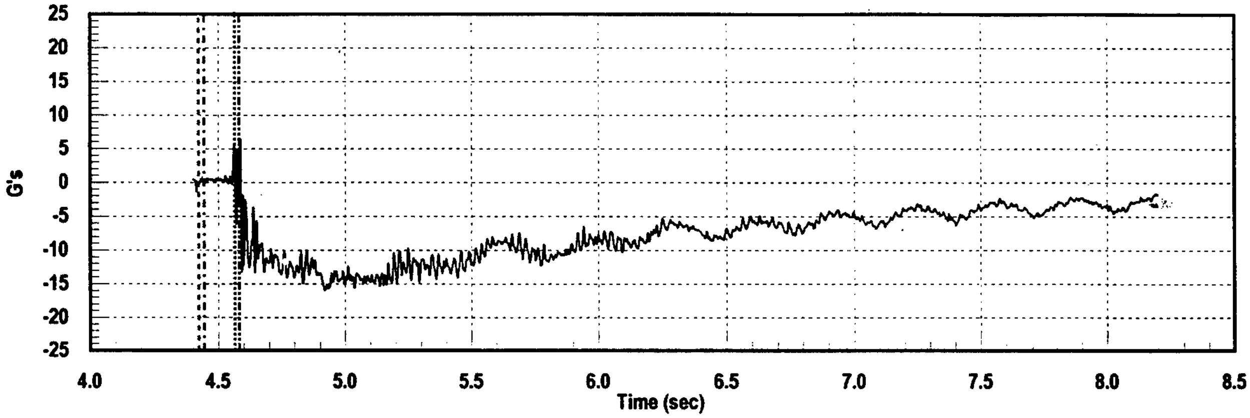
Seat Acceleration BZ



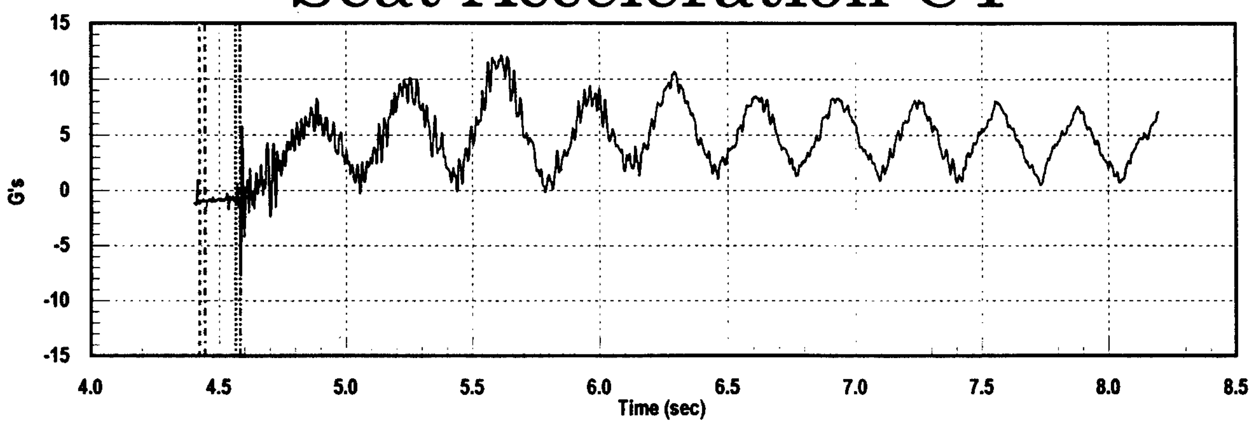
A-2

FL097516, 480 KEAS, 56,000 Ft

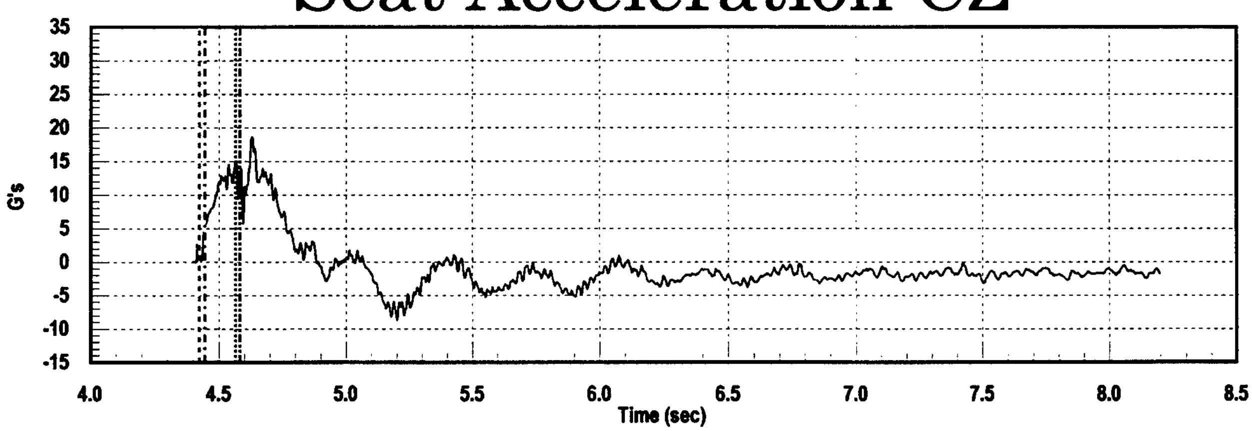
Seat Acceleration CX



Seat Acceleration CY



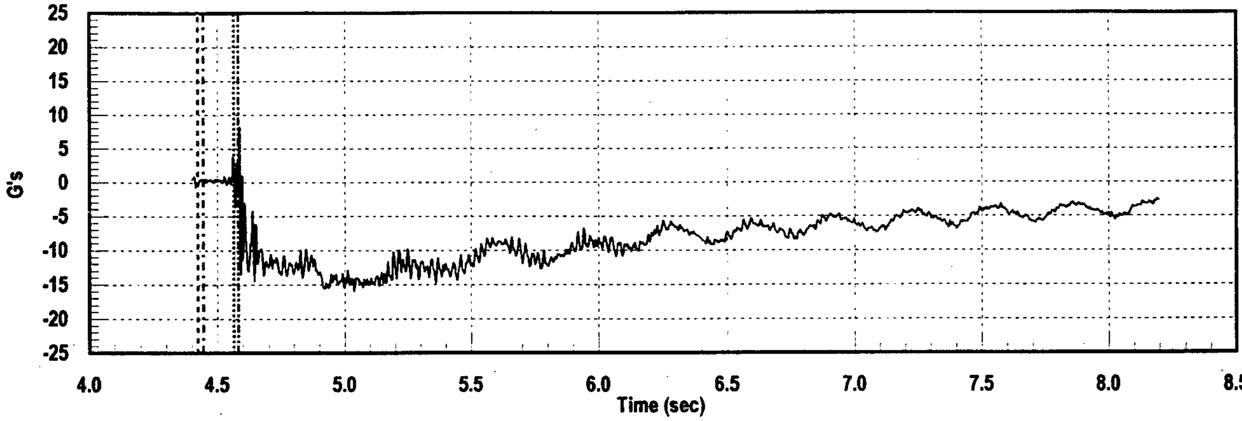
Seat Acceleration CZ



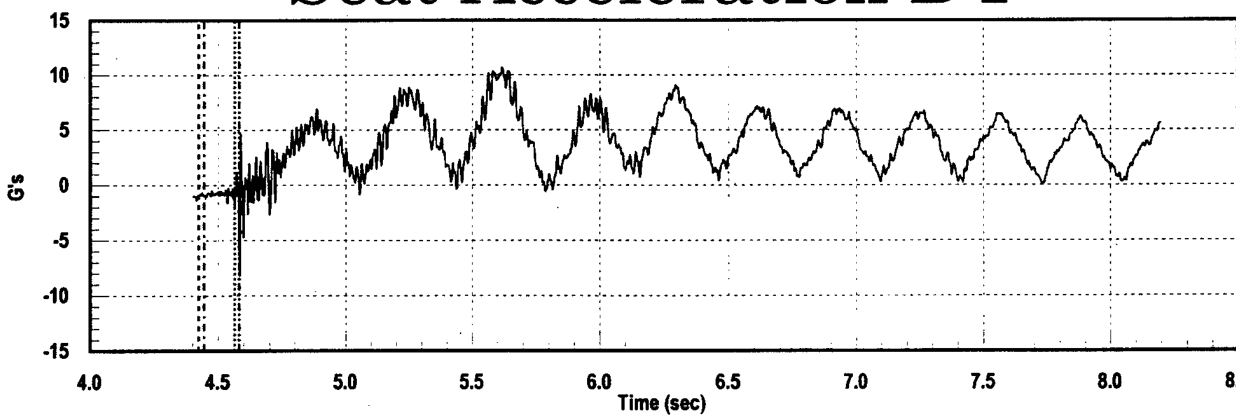
A-3

FL097516, 480 KEAS, 56,000 Ft

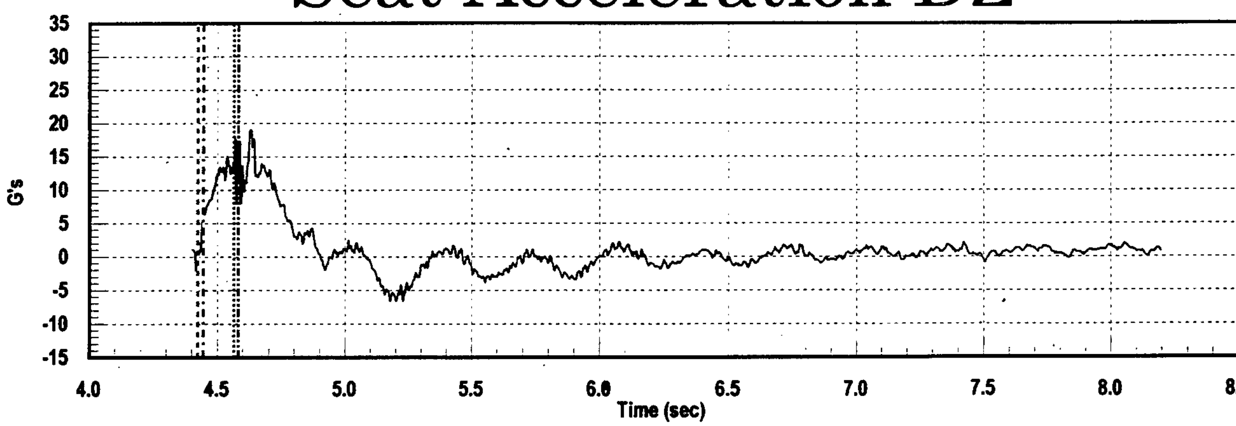
Seat Acceleration DX



Seat Acceleration DY

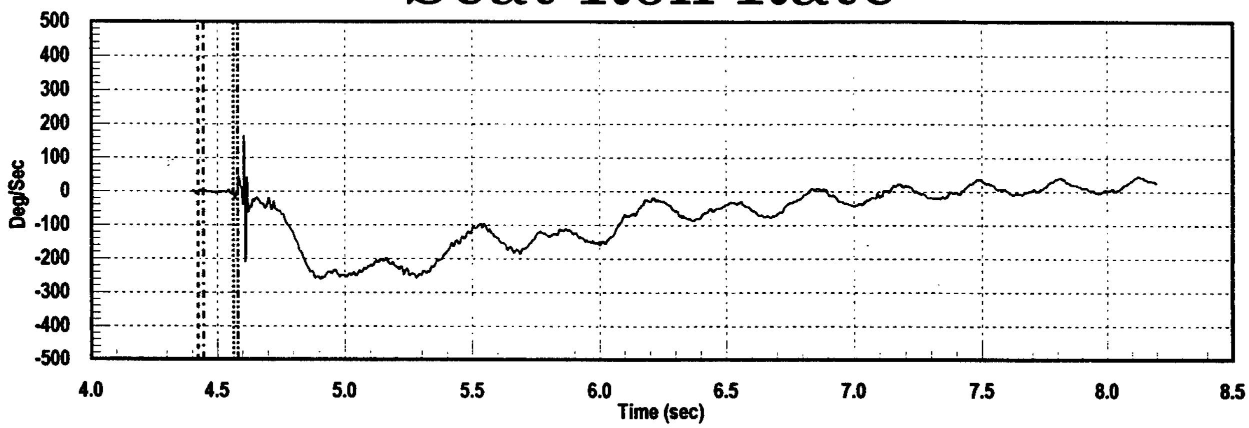


Seat Acceleration DZ

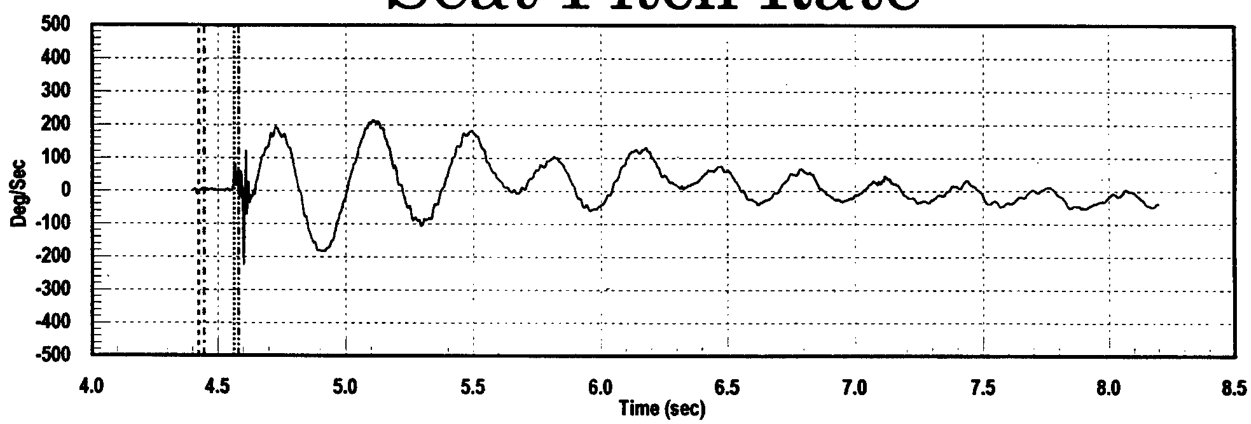


FL097516, 480 KEAS, 56,000 Ft

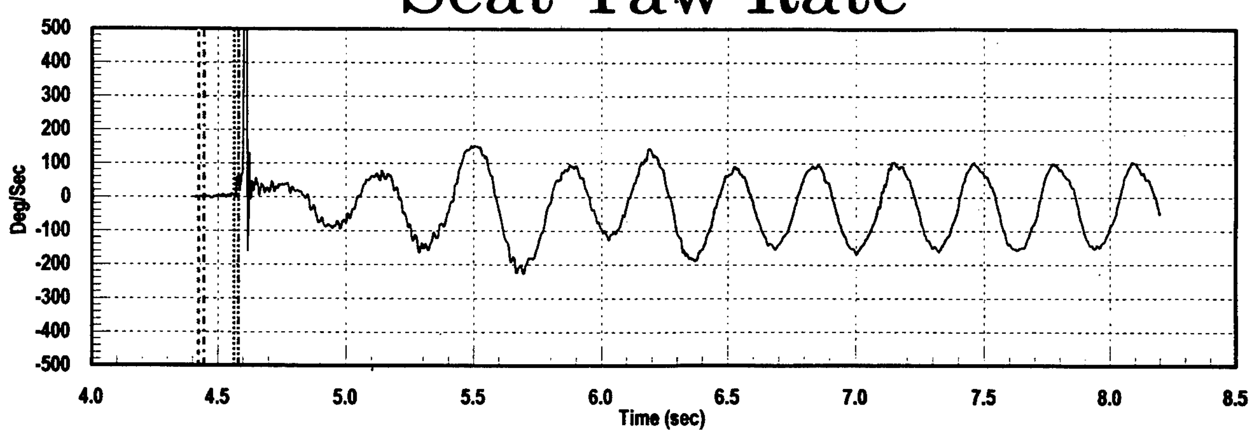
Seat Roll Rate



Seat Pitch Rate



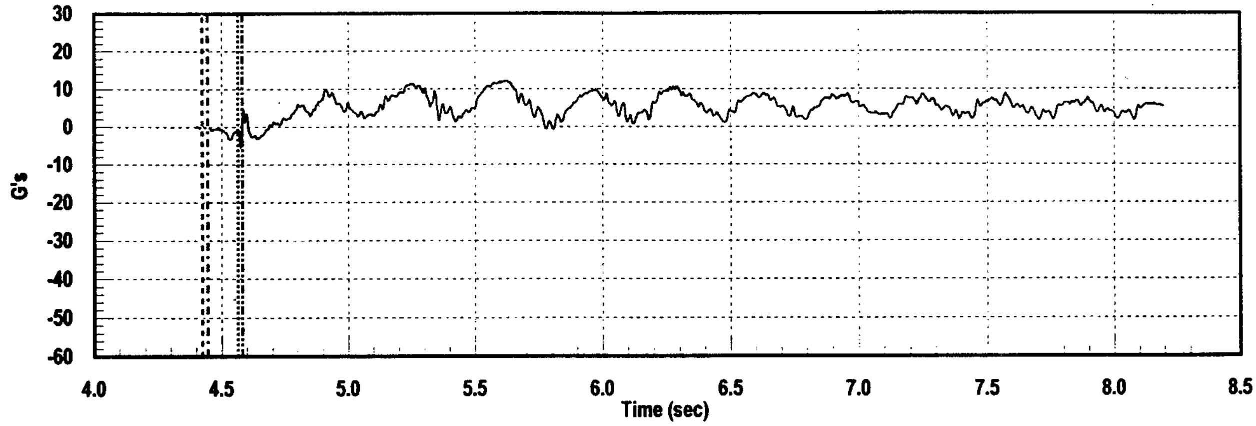
Seat Yaw Rate



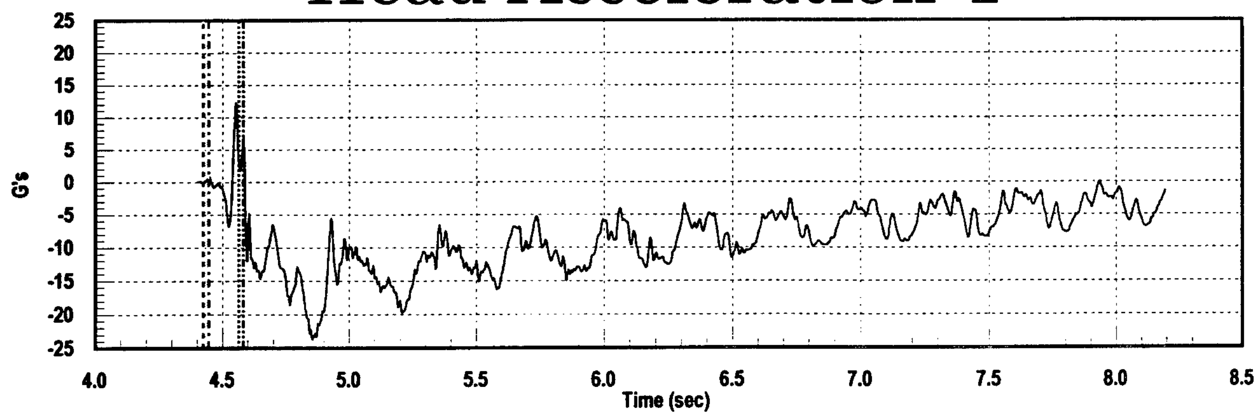
A-5

FL097516, 480 KEAS, 56,000 Ft

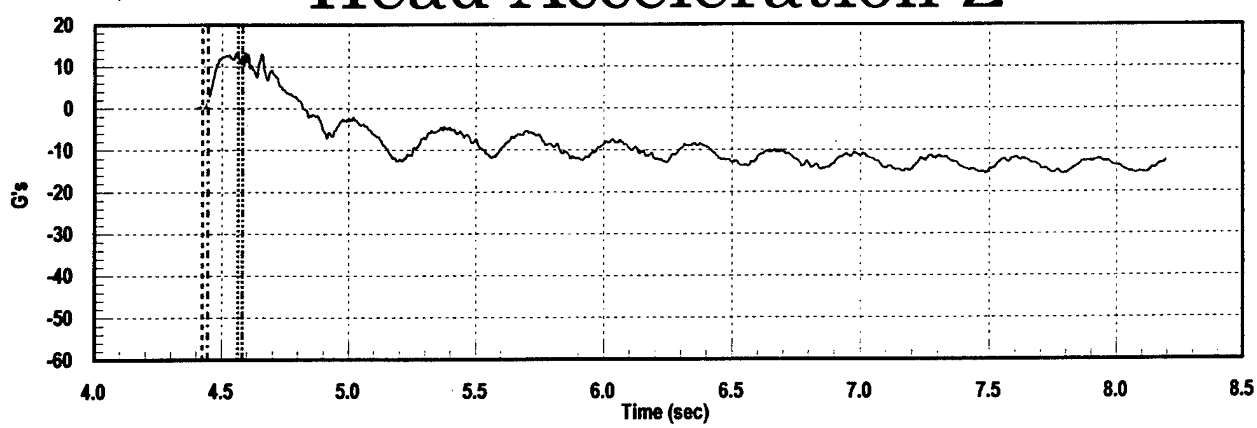
Head Acceleration X



Head Acceleration Y



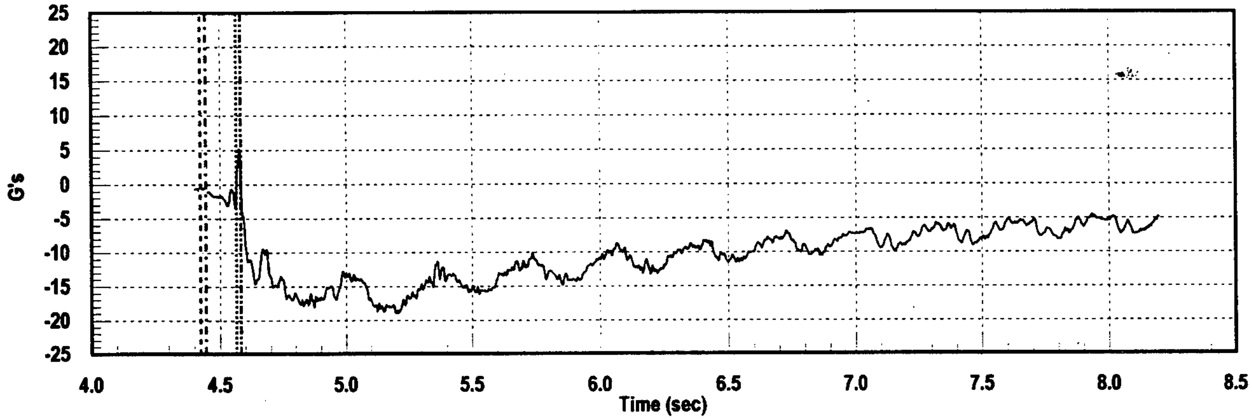
Head Acceleration Z



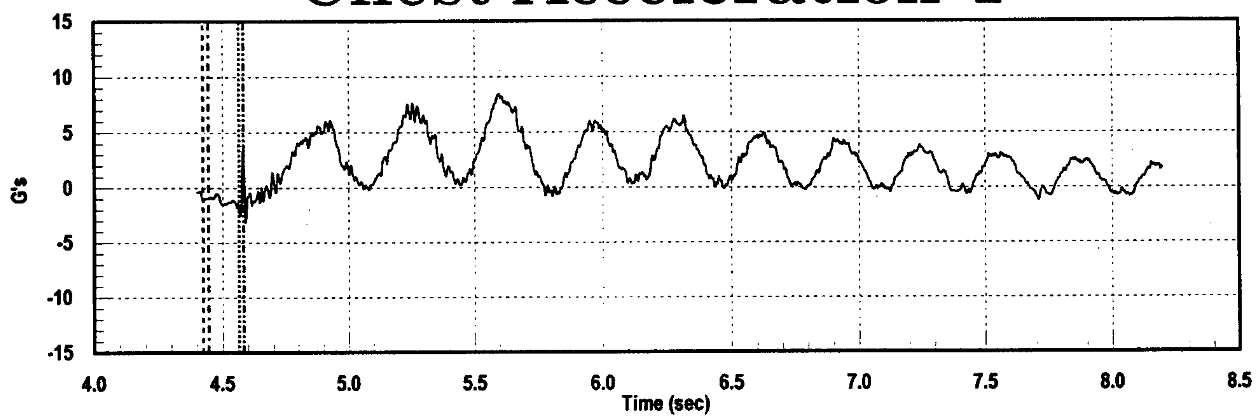
A-6

FL097516, 480 KEAS, 56,000 Ft

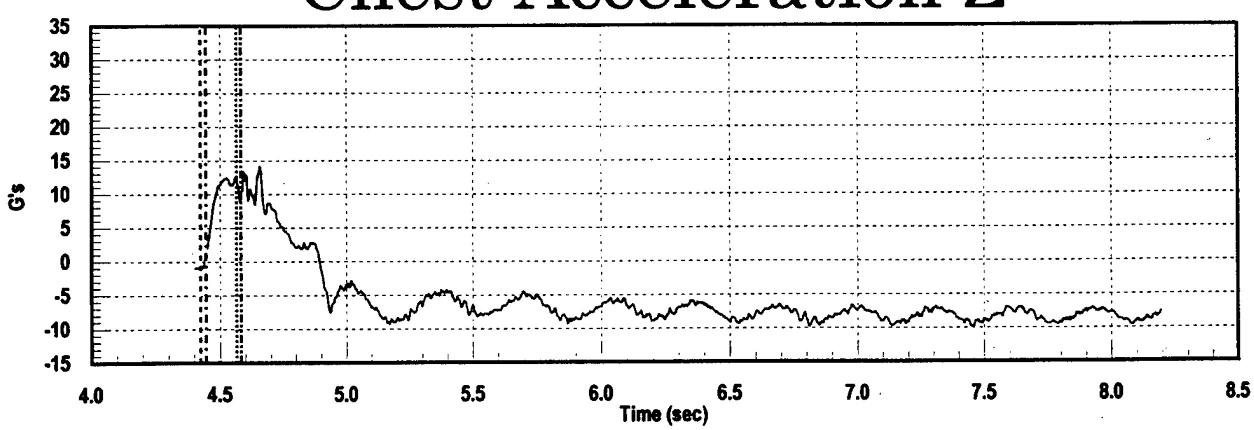
Chest Acceleration X



Chest Acceleration Y



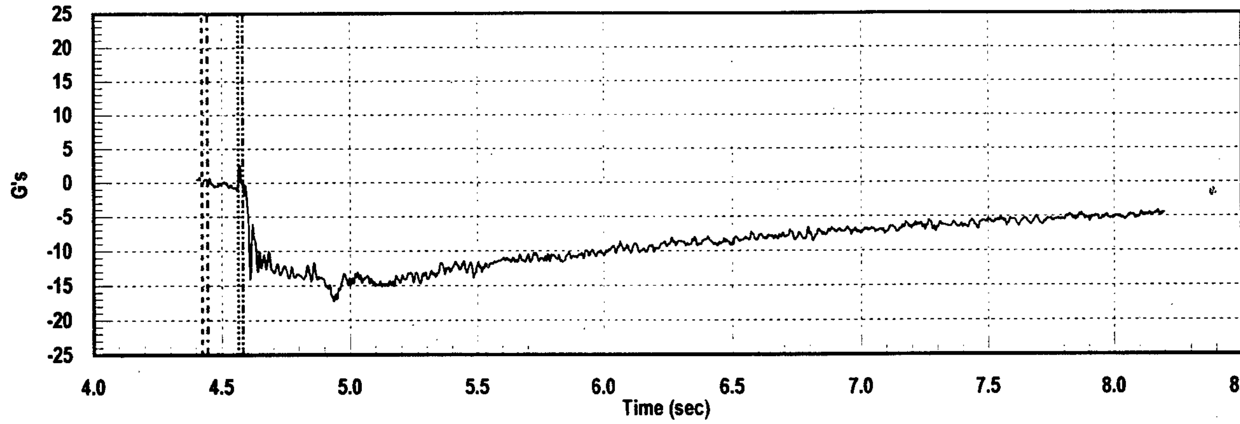
Chest Acceleration Z



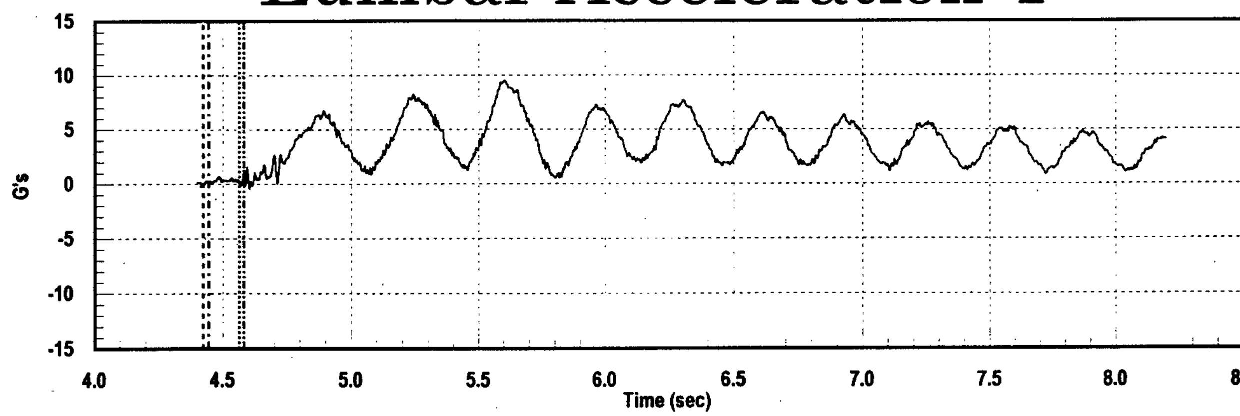
A-7

FL097516, 480 KEAS, 56,000 Ft

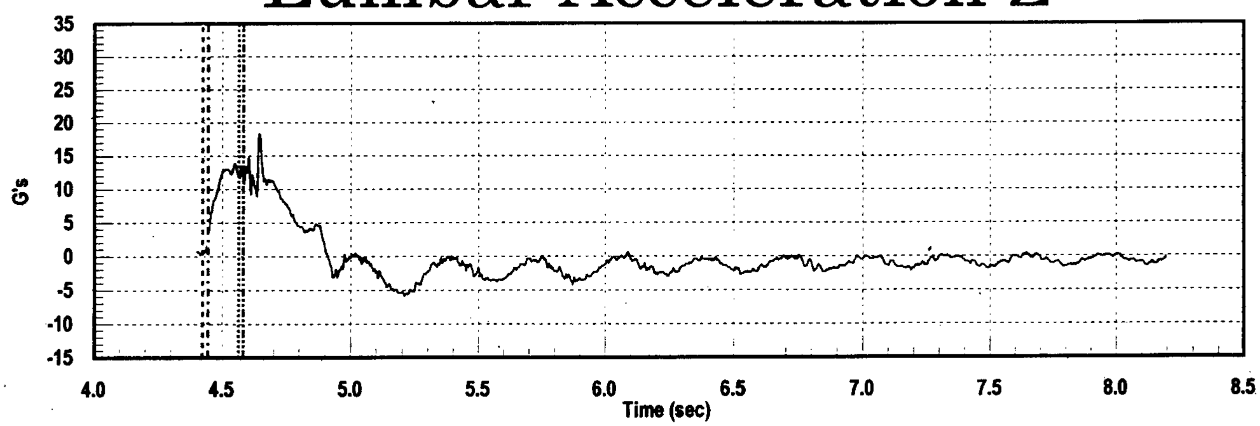
Lumbar Acceleration X



Lumbar Acceleration Y



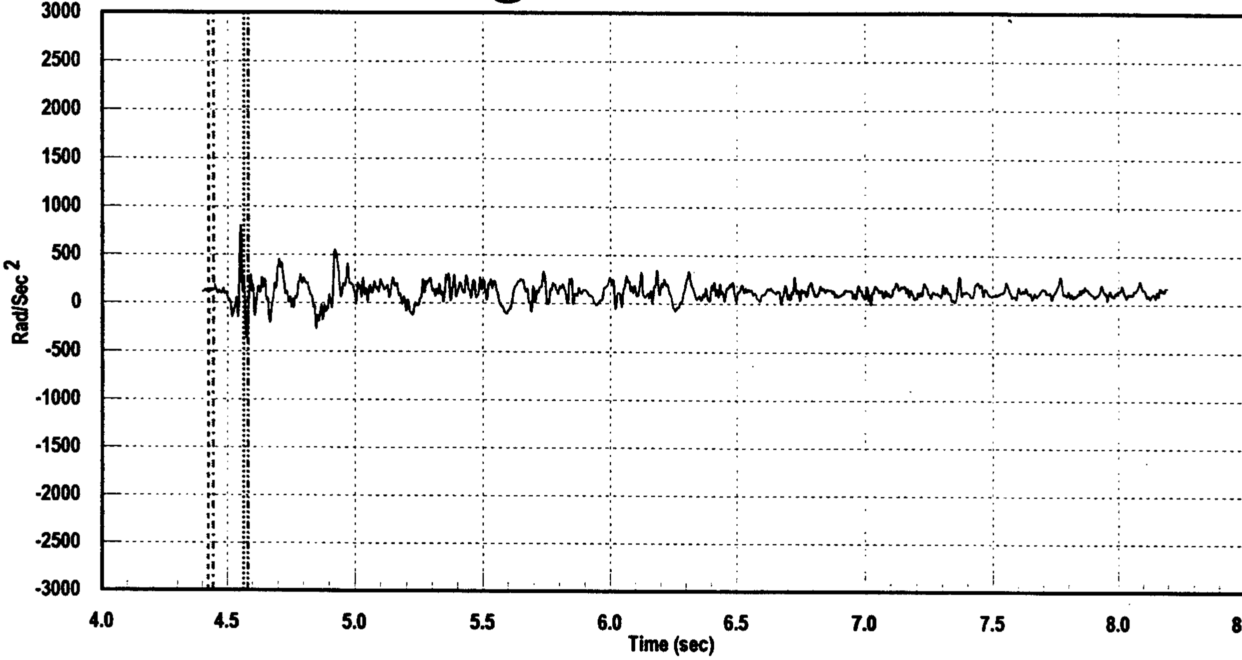
Lumbar Acceleration Z



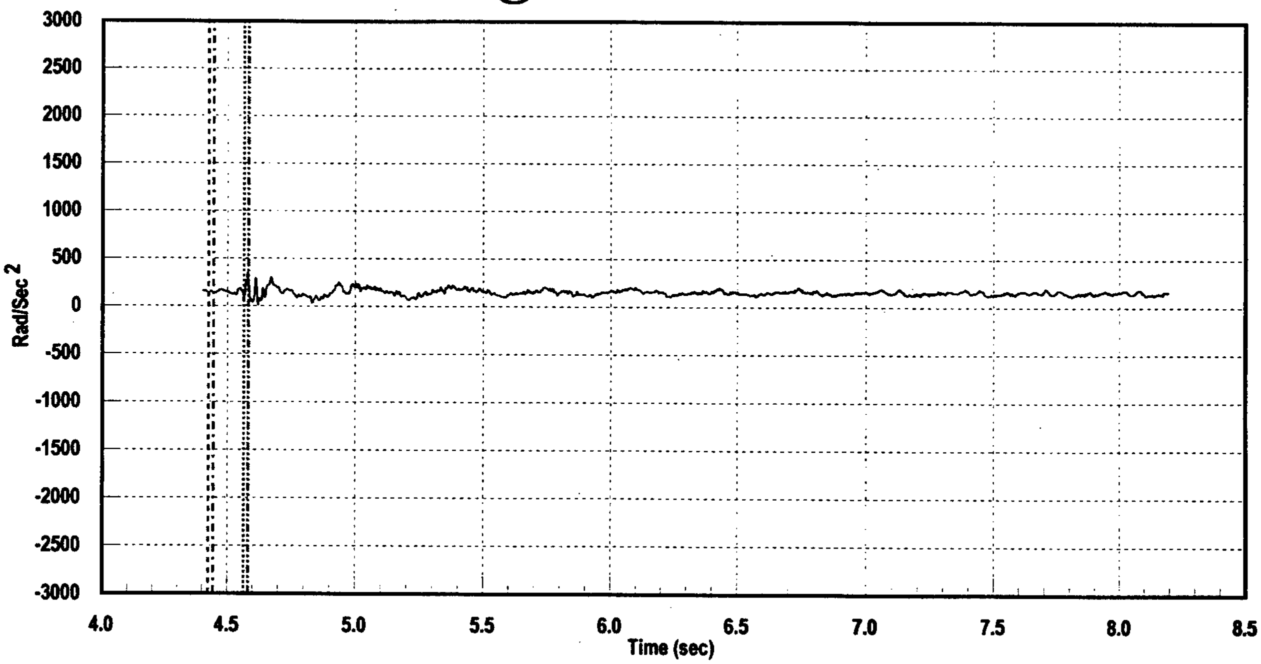
A-8

FL097516, 480 KEAS, 56,000 Ft

Head Angular Acceleration Y

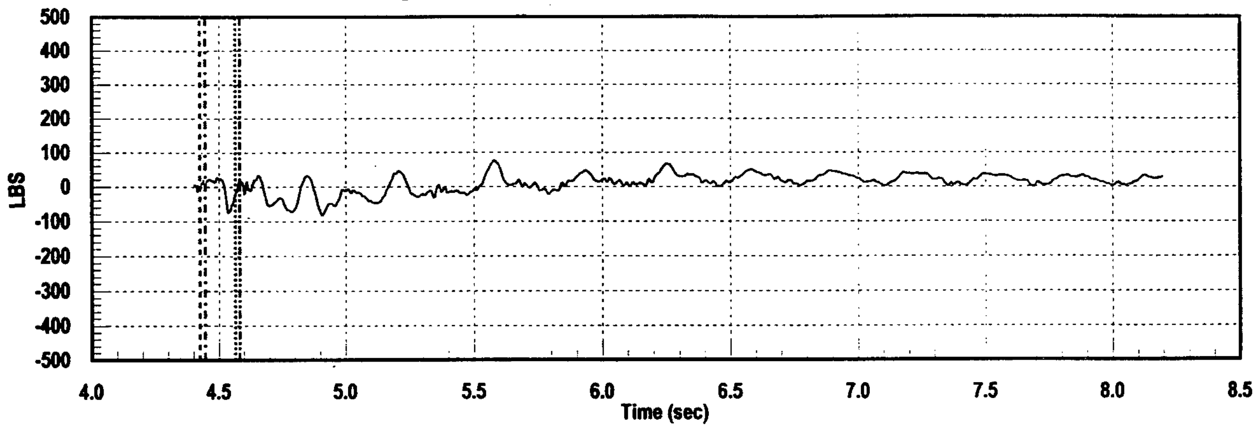


Chest Angular Acceleration Y

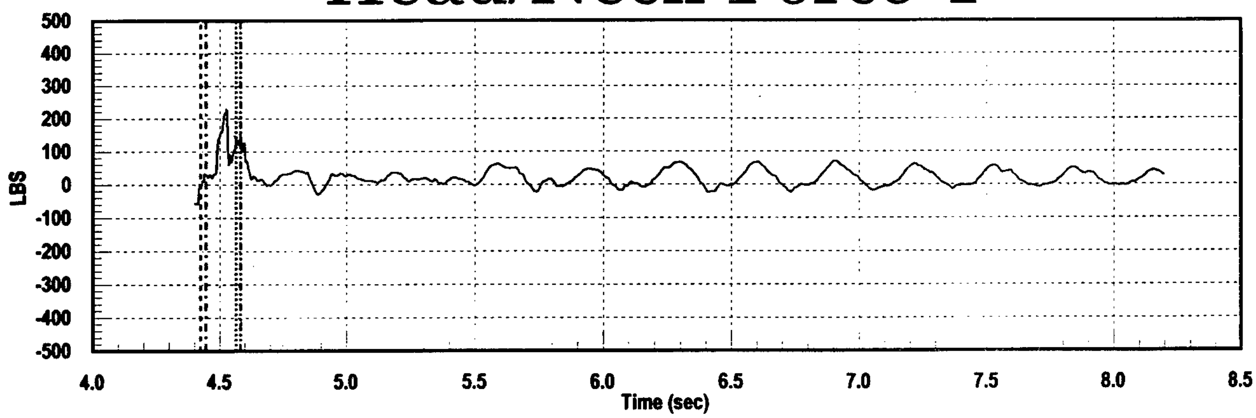


FL097516, 480 KEAS, 56,000 Ft

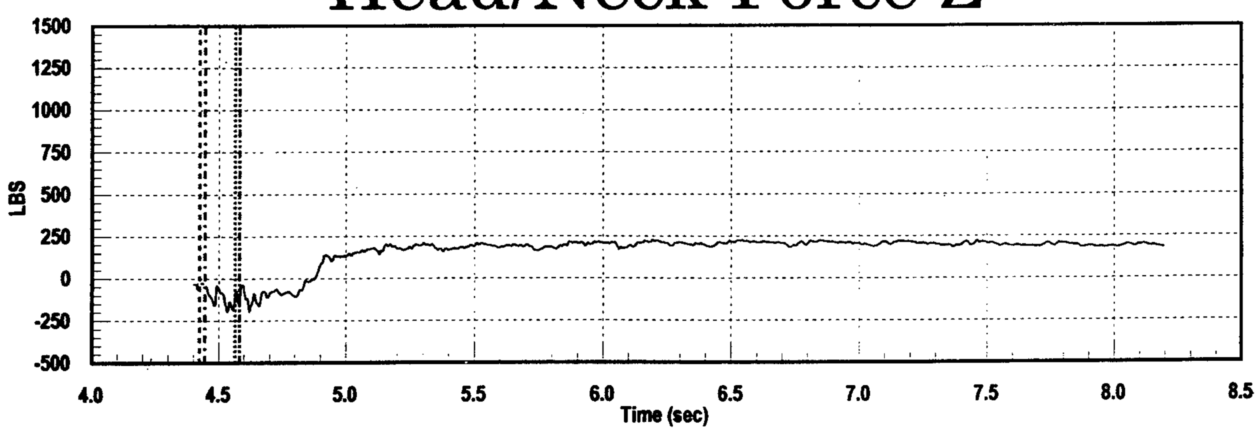
Head/Neck Force X



Head/Neck Force Y

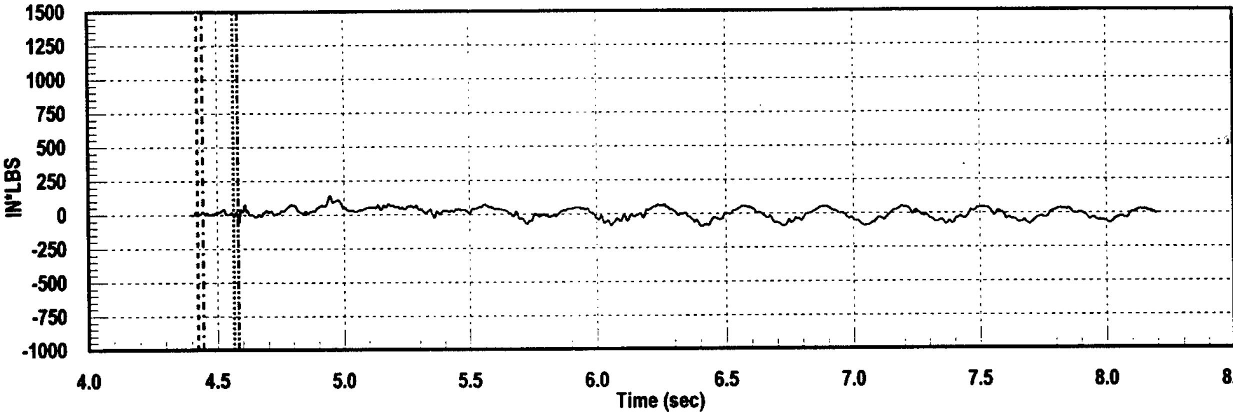


Head/Neck Force Z

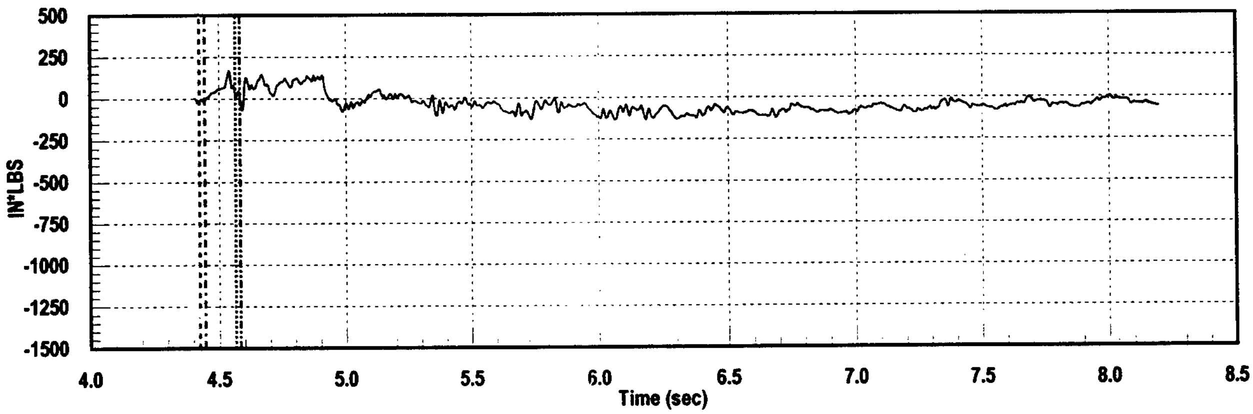


FL097516, 480 KEAS, 56,000 Ft

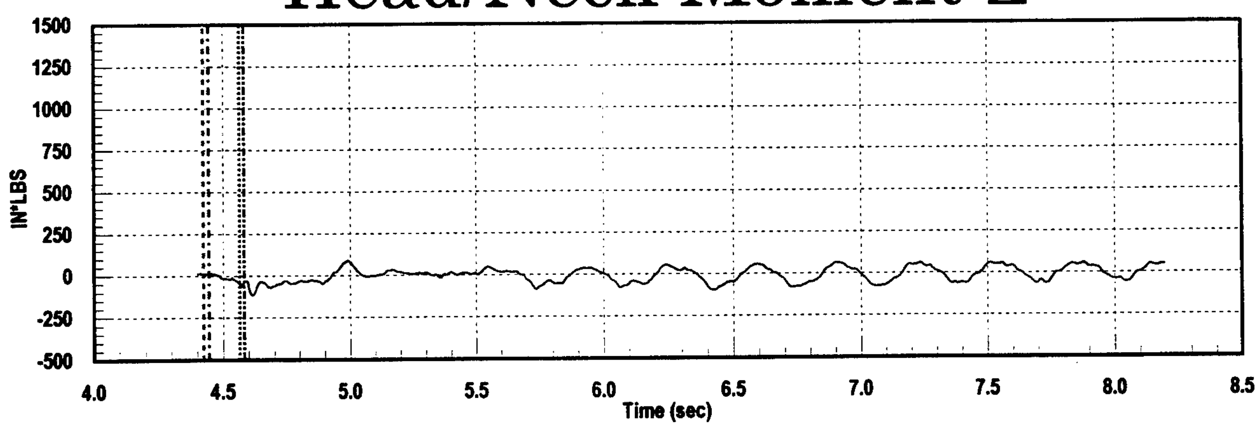
Head/Neck Moment X



Head/Neck Moment Y



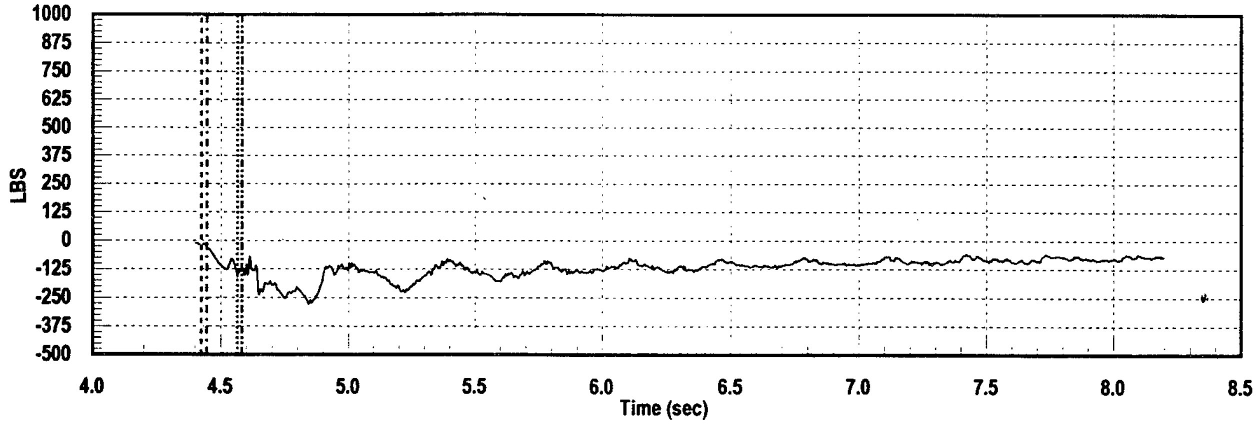
Head/Neck Moment Z



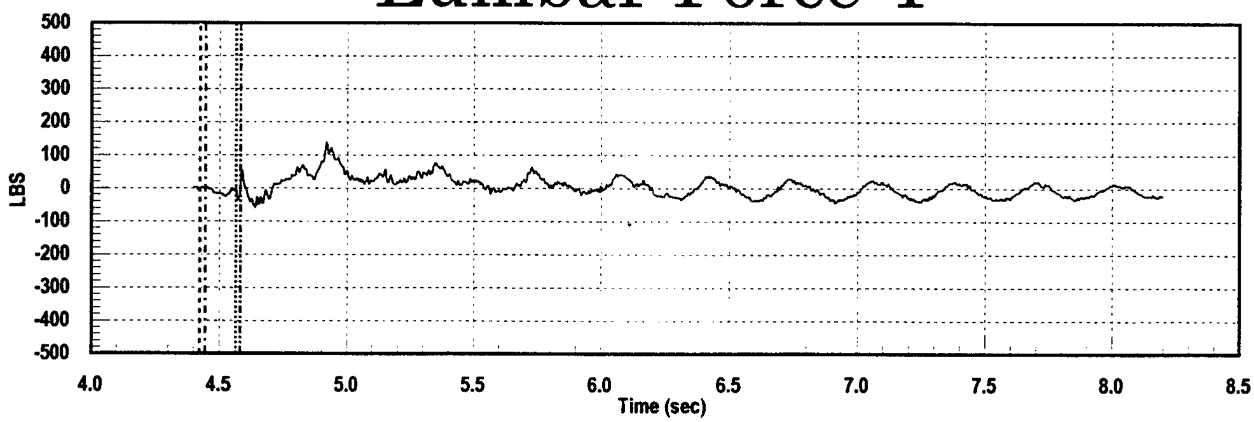
A-11

FL097516, 480 KEAS, 56,000 Ft

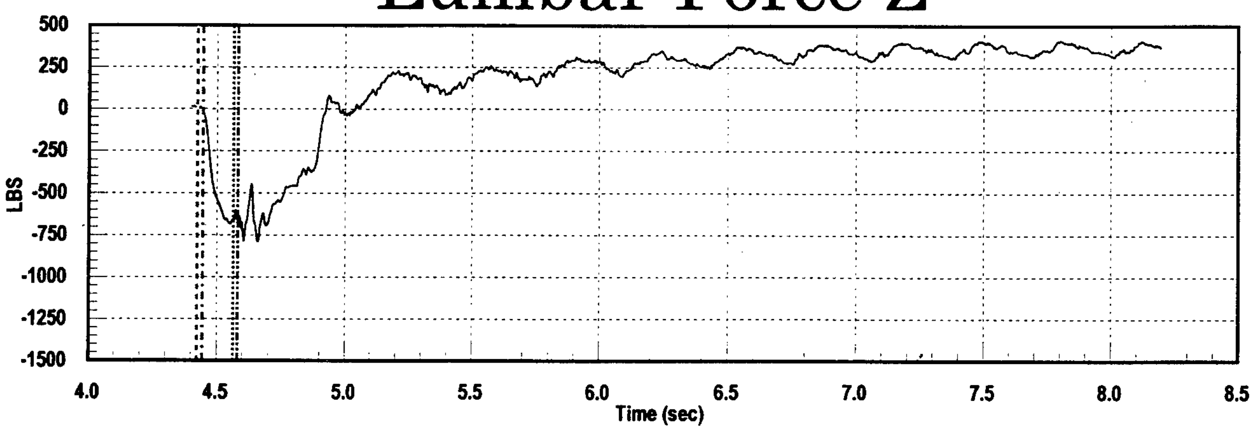
Lumbar Force X



Lumbar Force Y



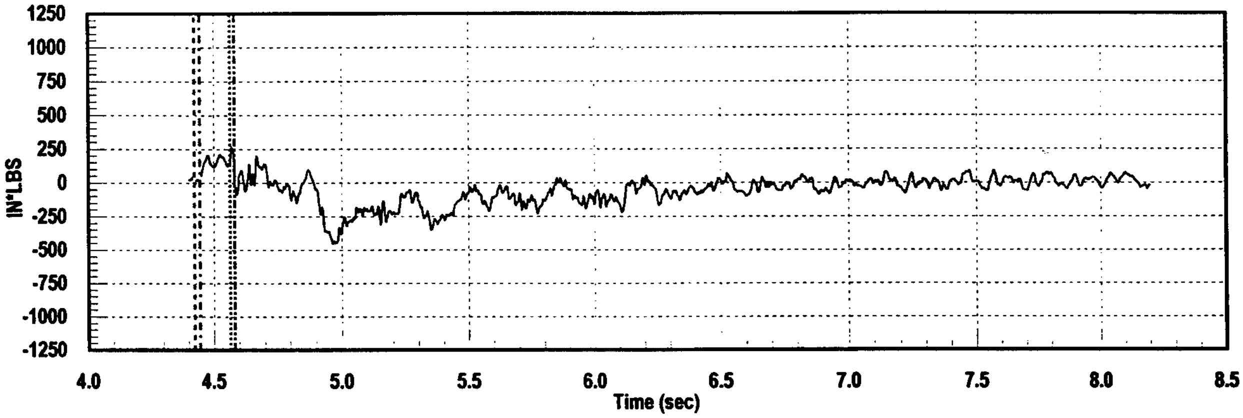
Lumbar Force Z



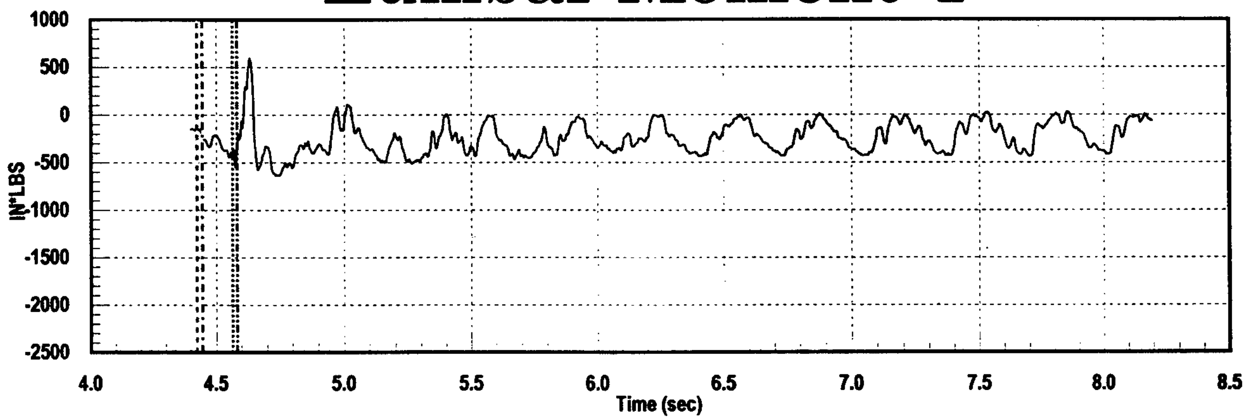
A-12

FL097516, 480 KEAS, 56,000 Ft

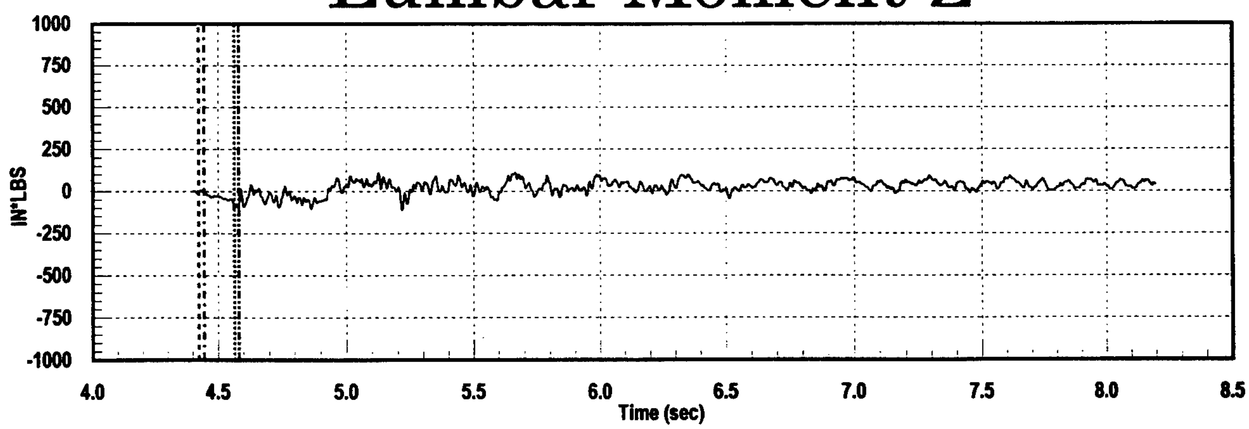
Lumbar Moment X



Lumbar Moment Y



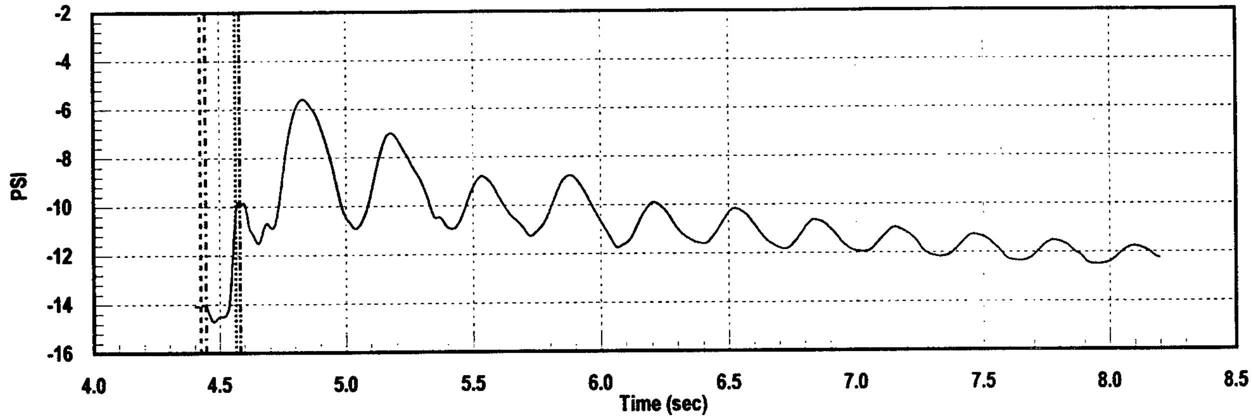
Lumbar Moment Z



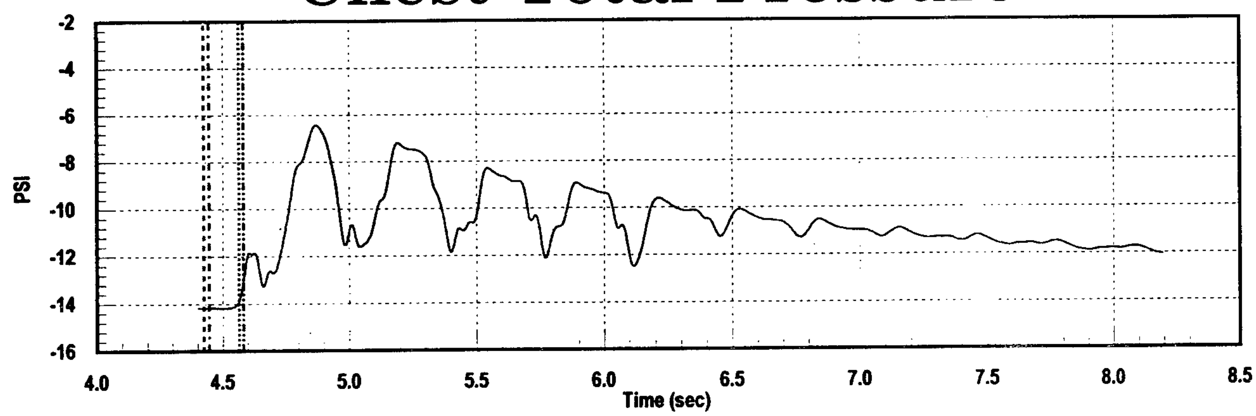
A-13

FL097516, 480 KEAS, 56,000 Ft

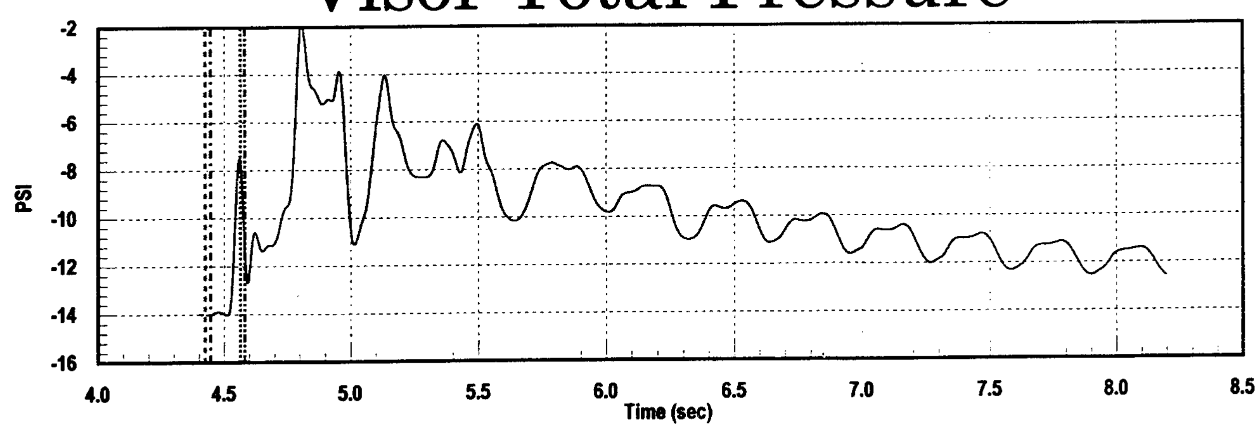
Windblast Deflector Total Pressure



Chest Total Pressure



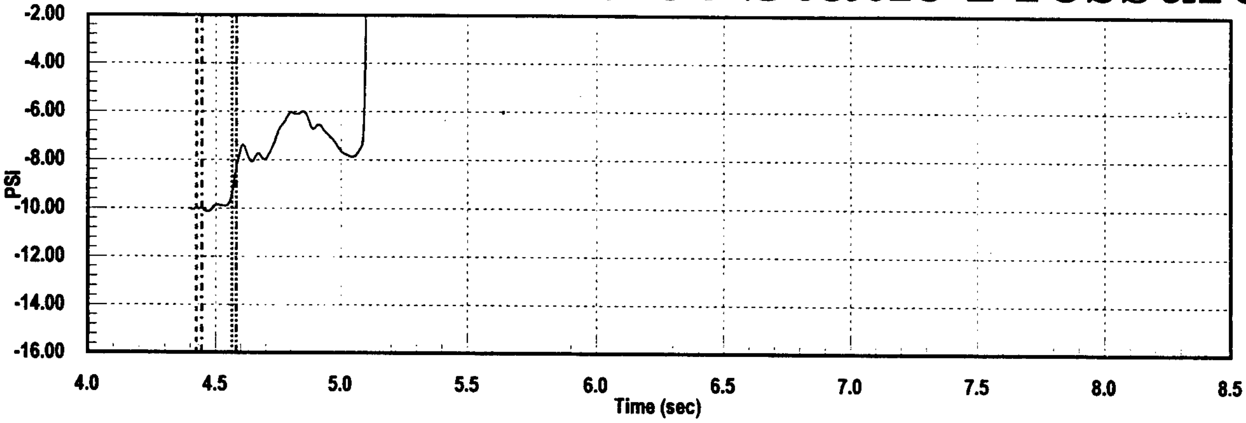
Visor Total Pressure



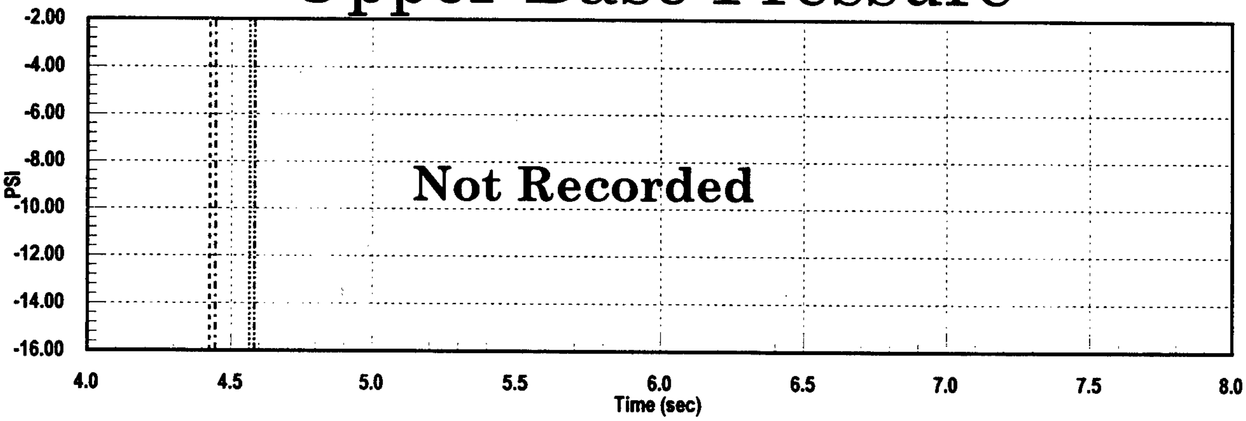
A-14

FL097516, 480 KEAS, 56,000 Ft

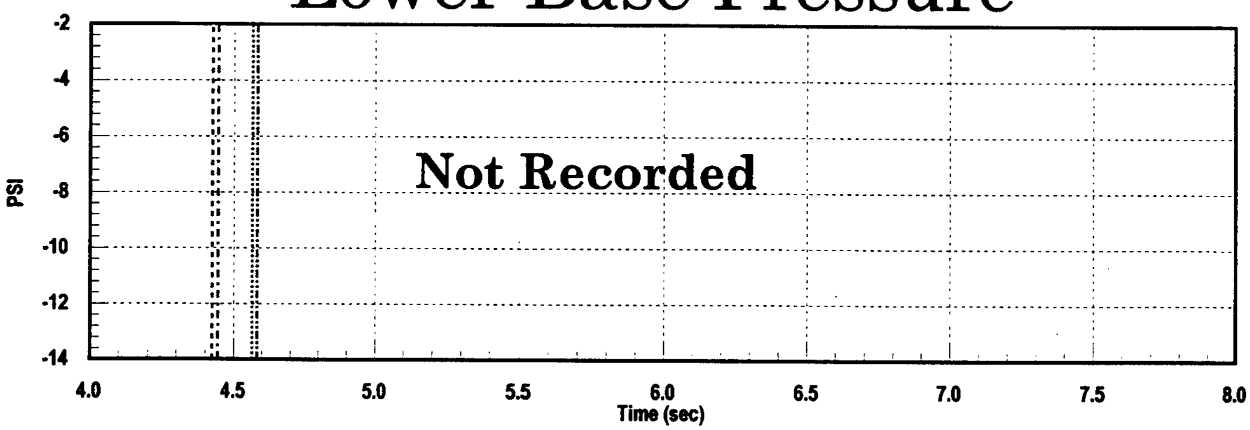
Windblast Deflector Static Pressure



Upper Base Pressure

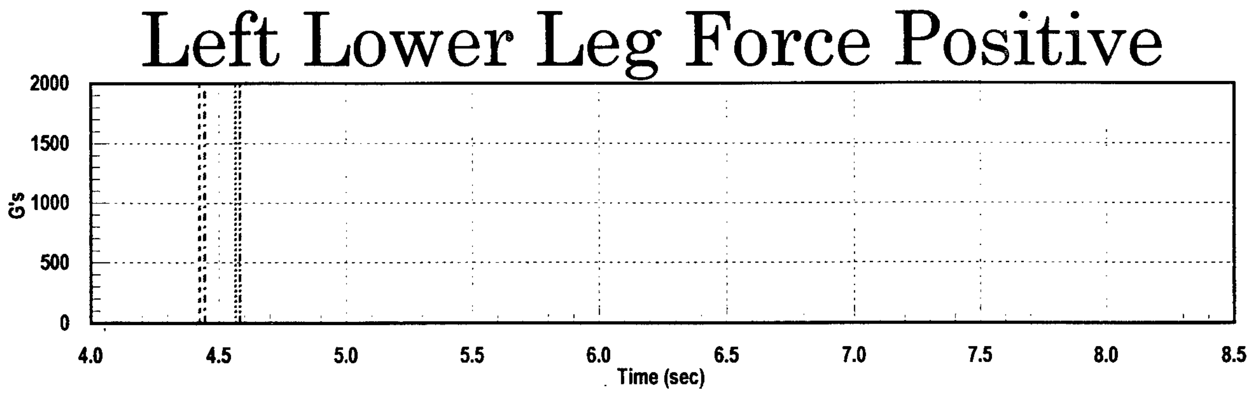


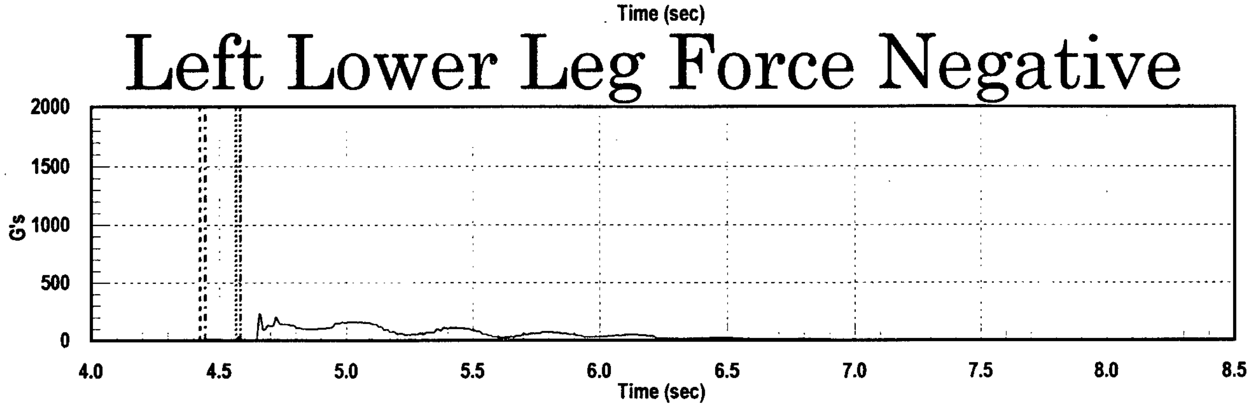
Lower Base Pressure

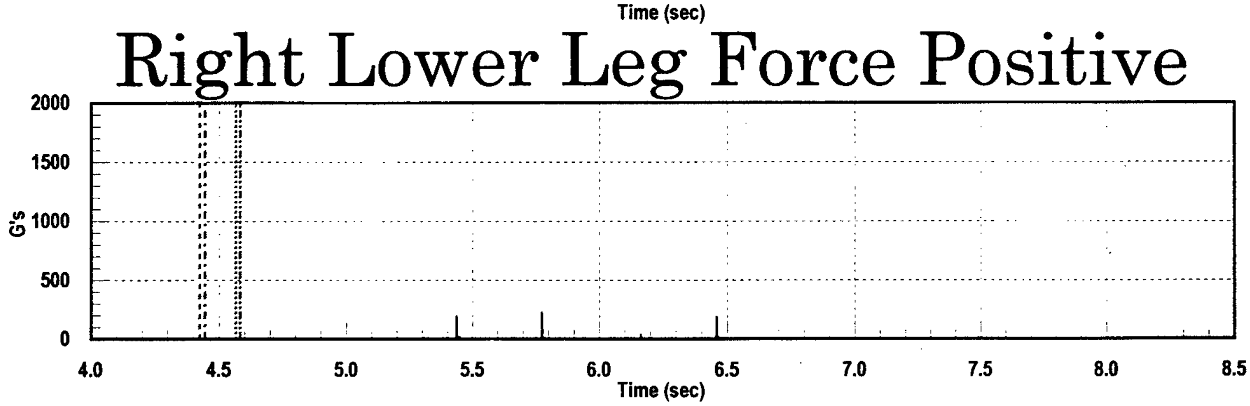


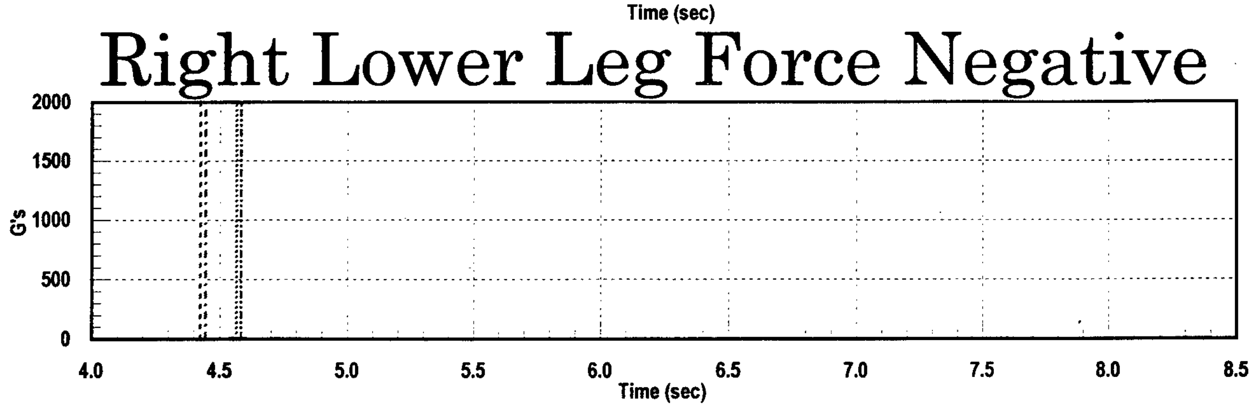
A-15

FL097516, 480 KEAS, 56,000 Ft





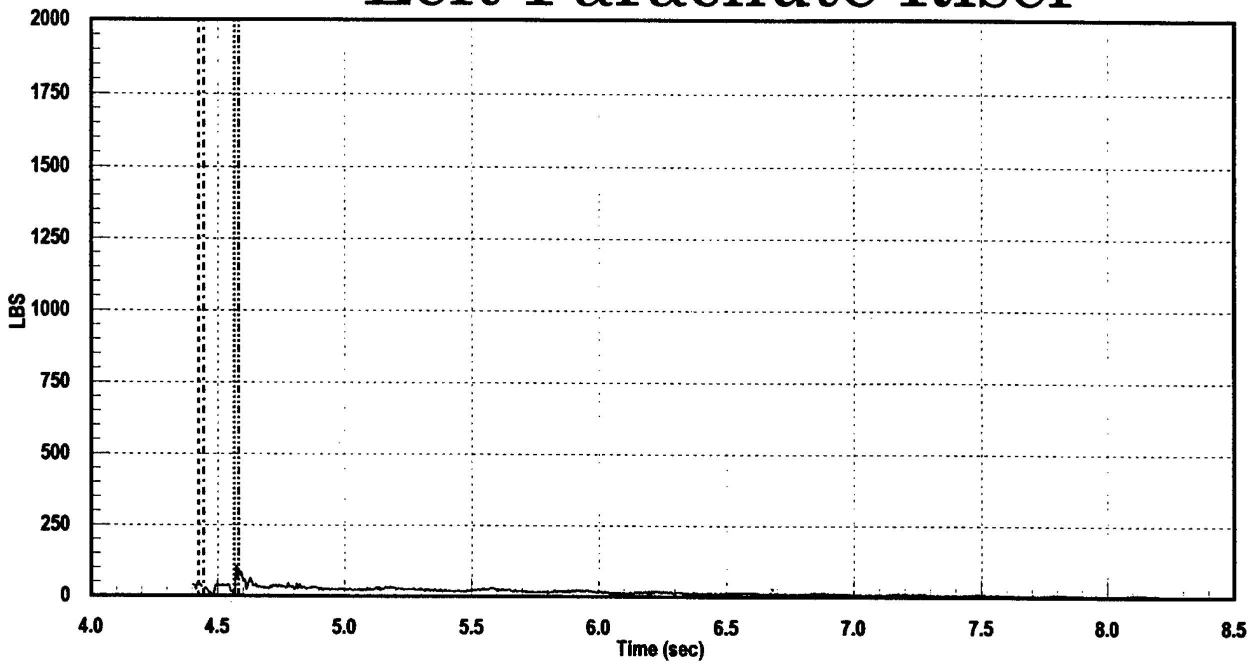




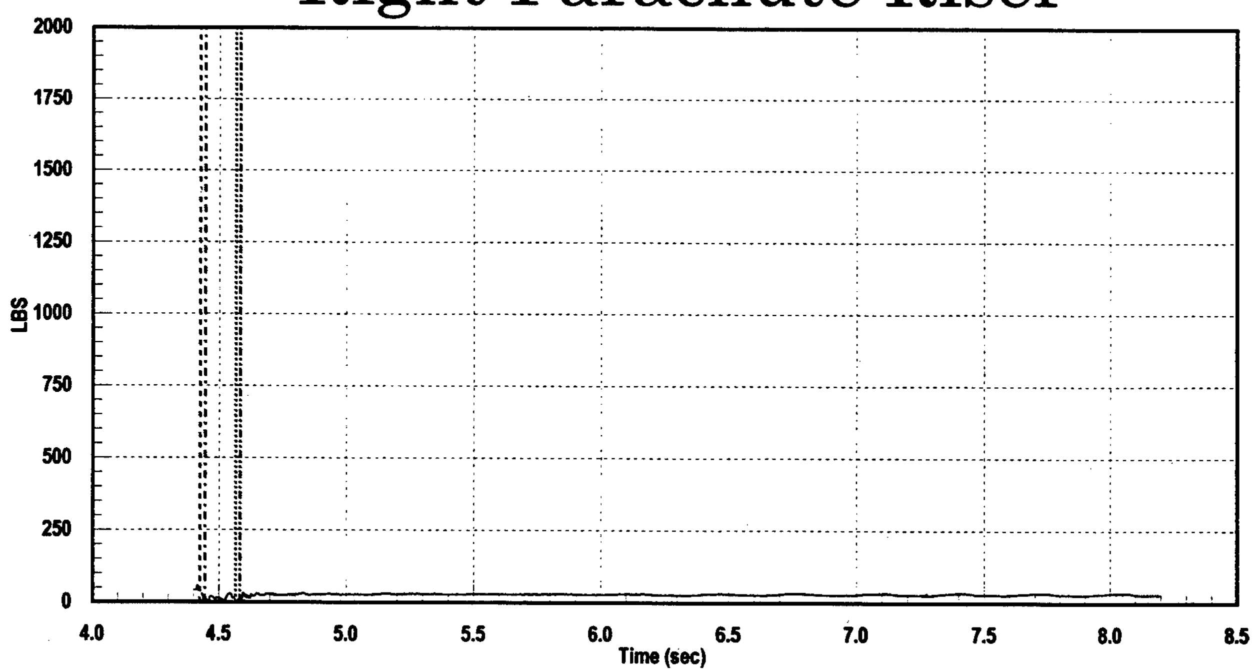
A-16

FL097516, 480 KEAS, 56,000 Ft

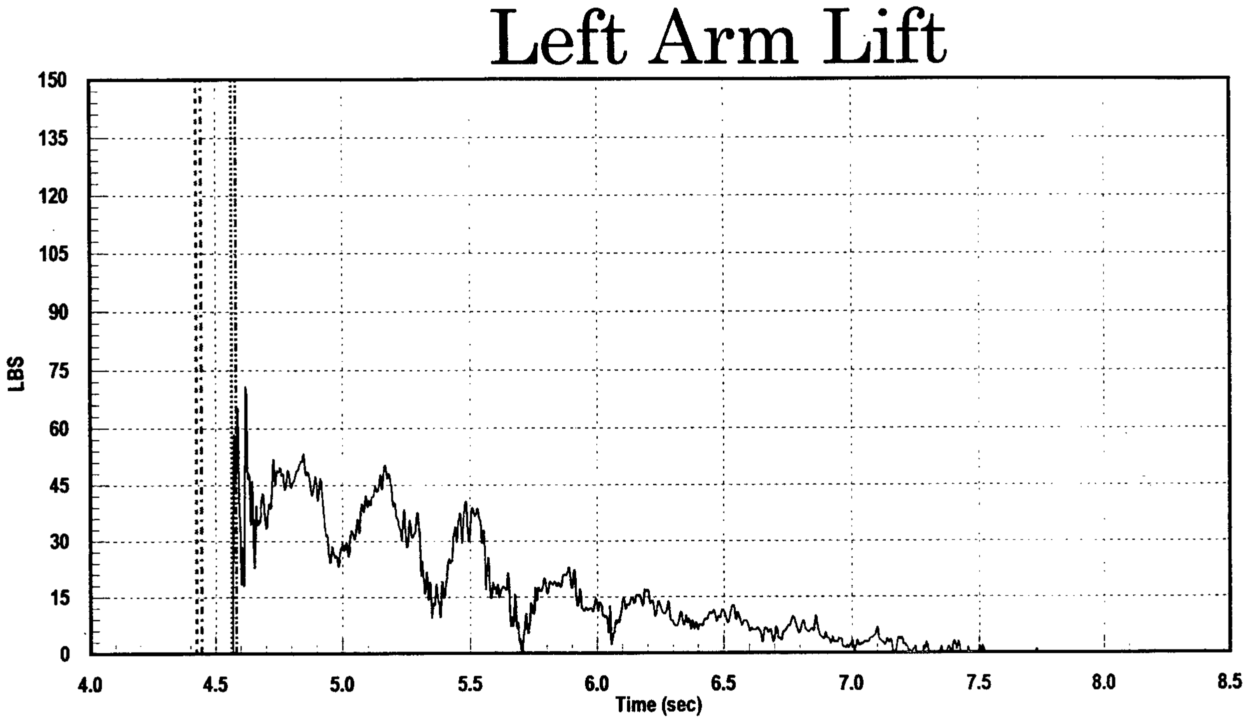
Left Parachute Riser

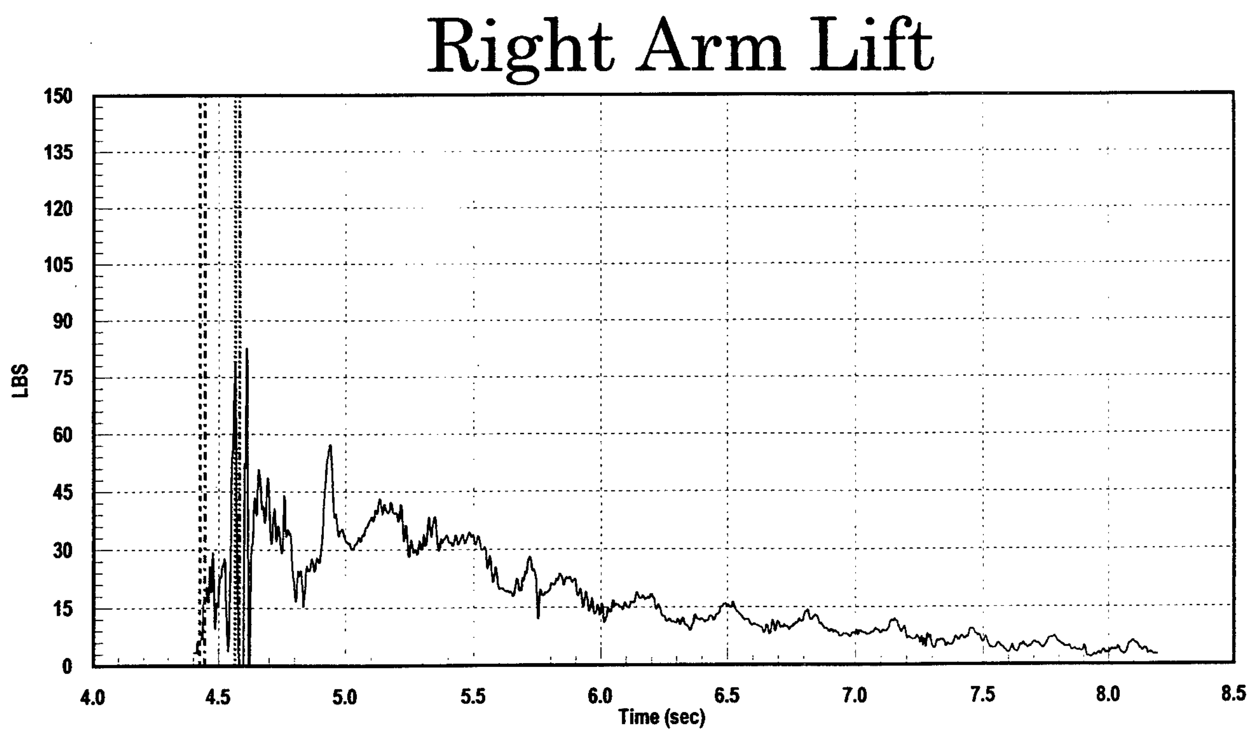


Right Parachute Riser



FL097516, 480 KEAS, 56,000 Ft

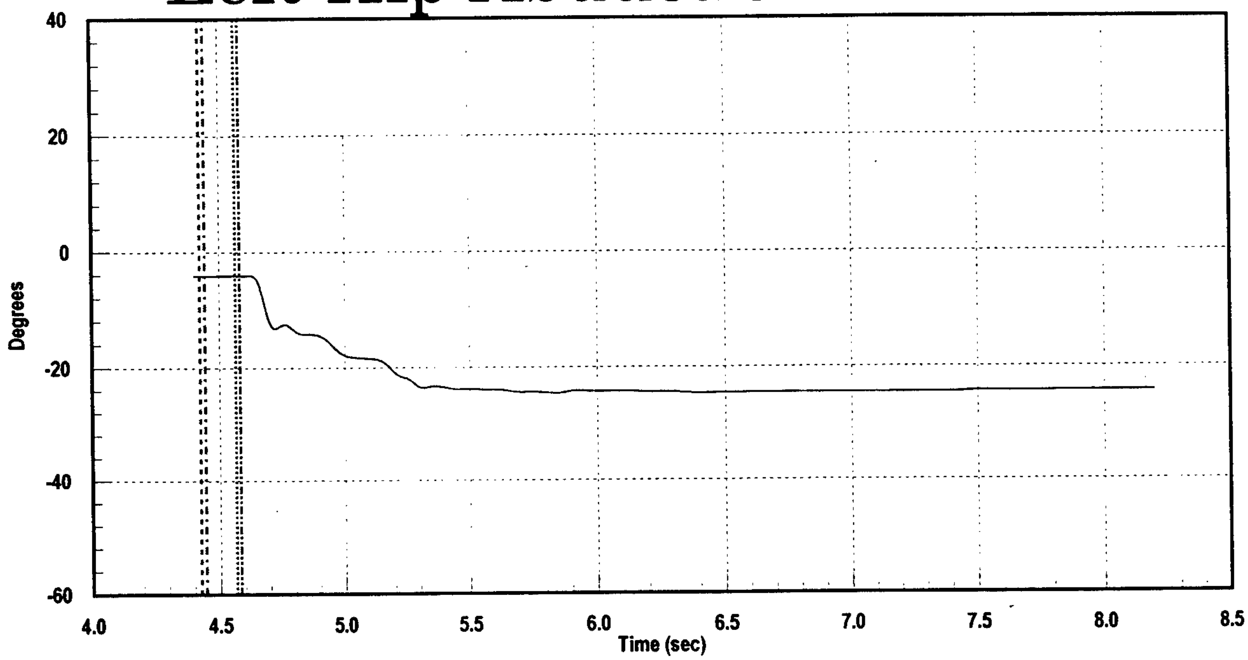




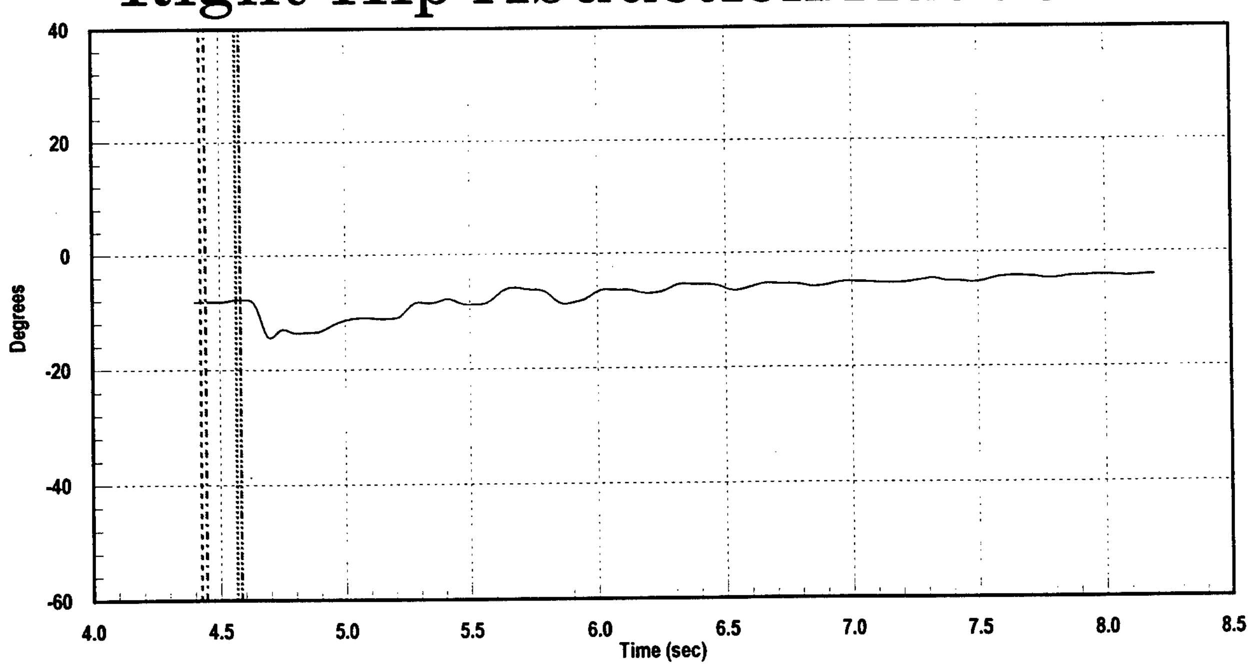
A-18

FL097516, 480 KEAS, 56,000 Ft

Left Hip Abduction/Adduction



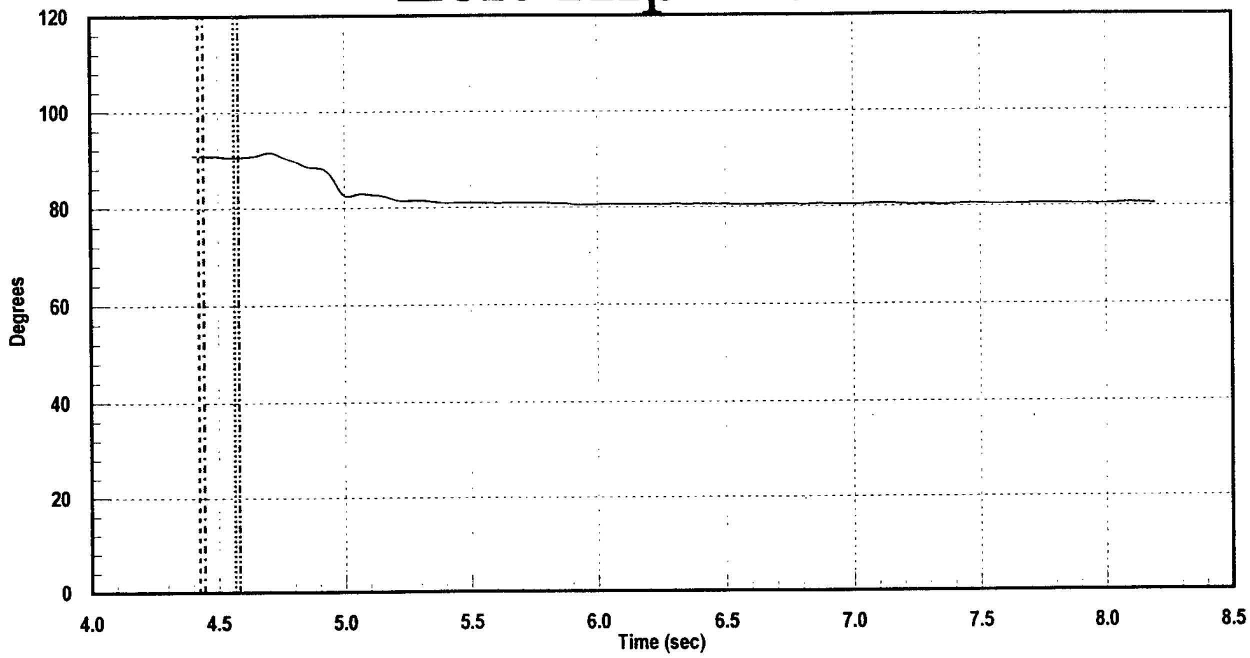
Right Hip Abduction/Adduction



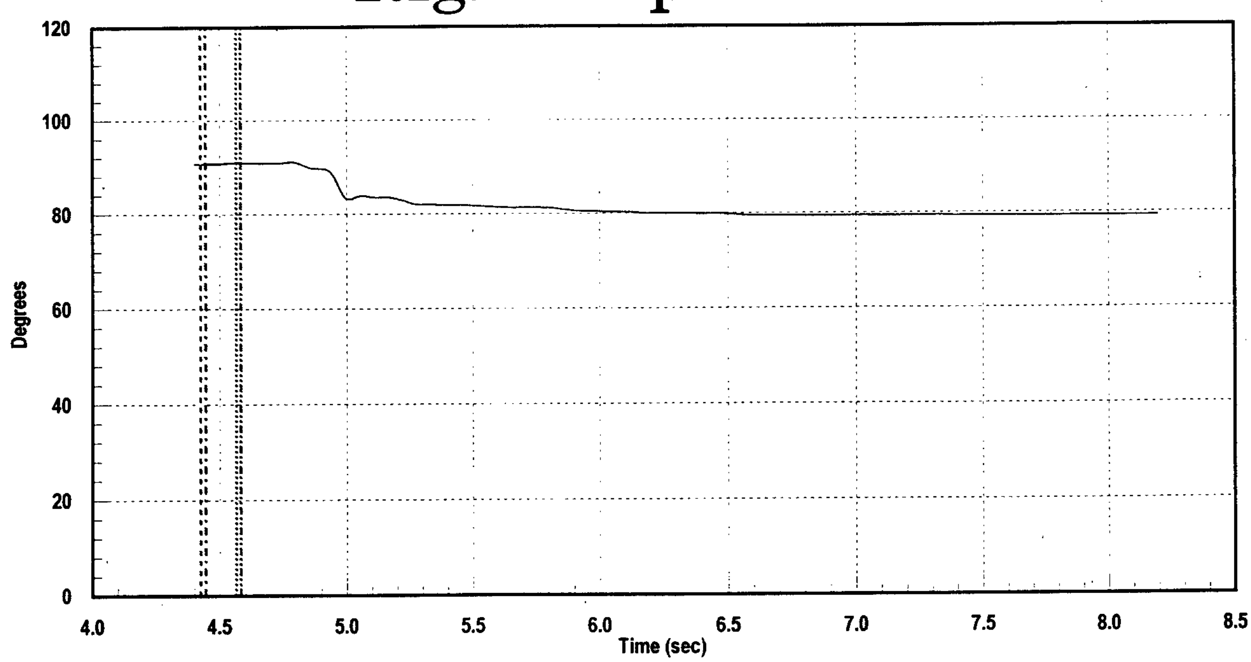
A-19

FL097516, 480 KEAS, 56,000 Ft

Left Hip Flexion



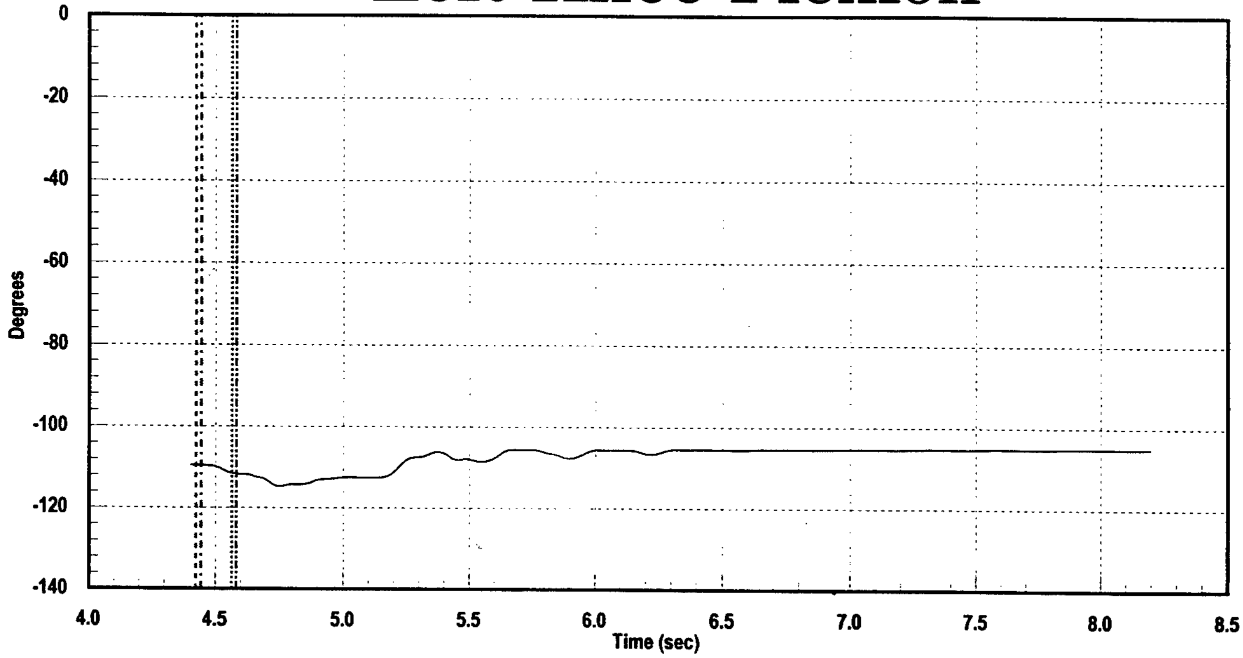
Right Hip Flexion



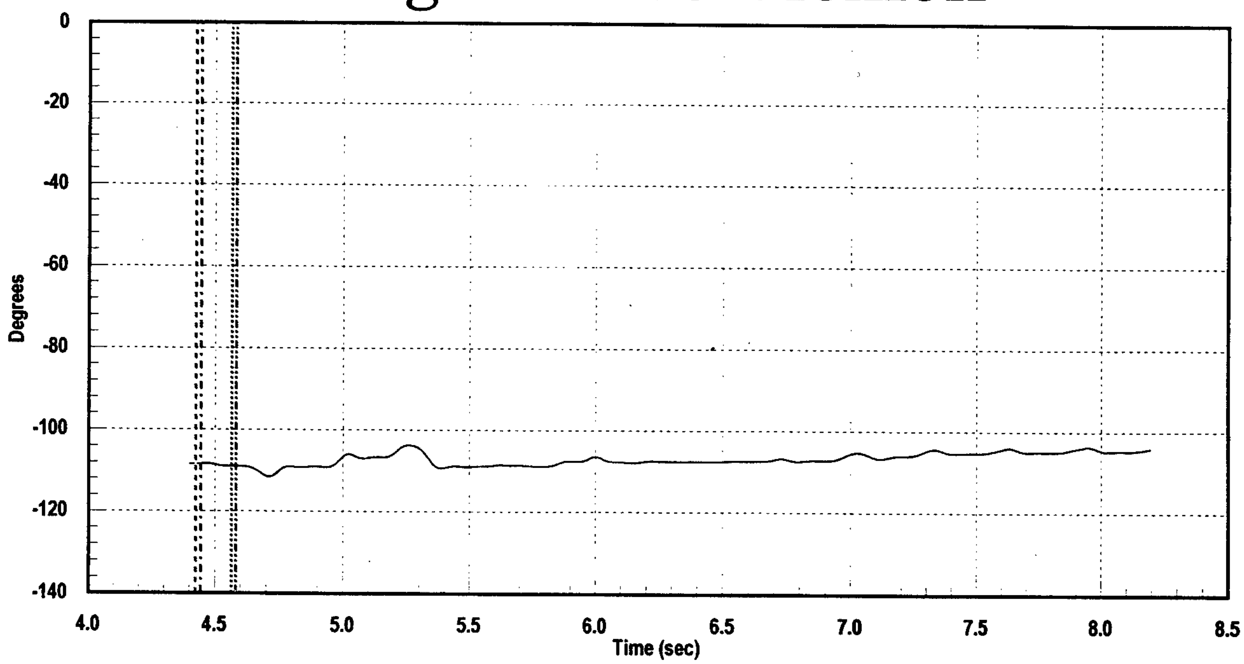
A-20

FL097516, 480 KEAS, 56,000 Ft

Left Knee Flexion



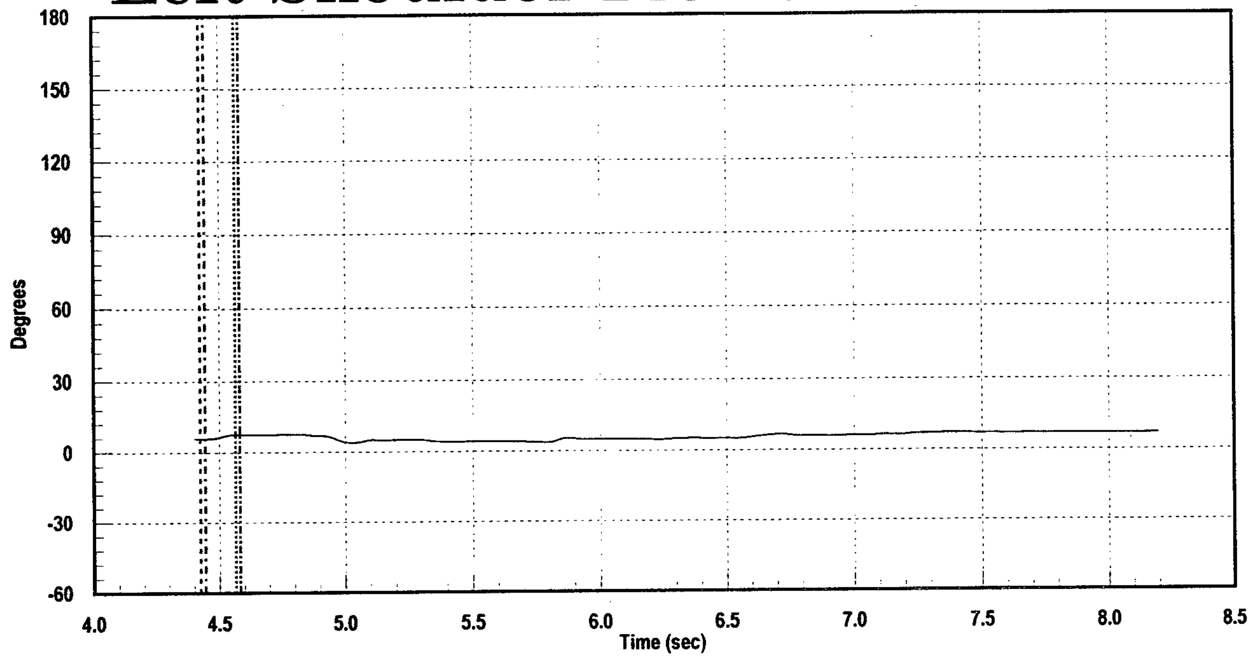
Right Knee Flexion



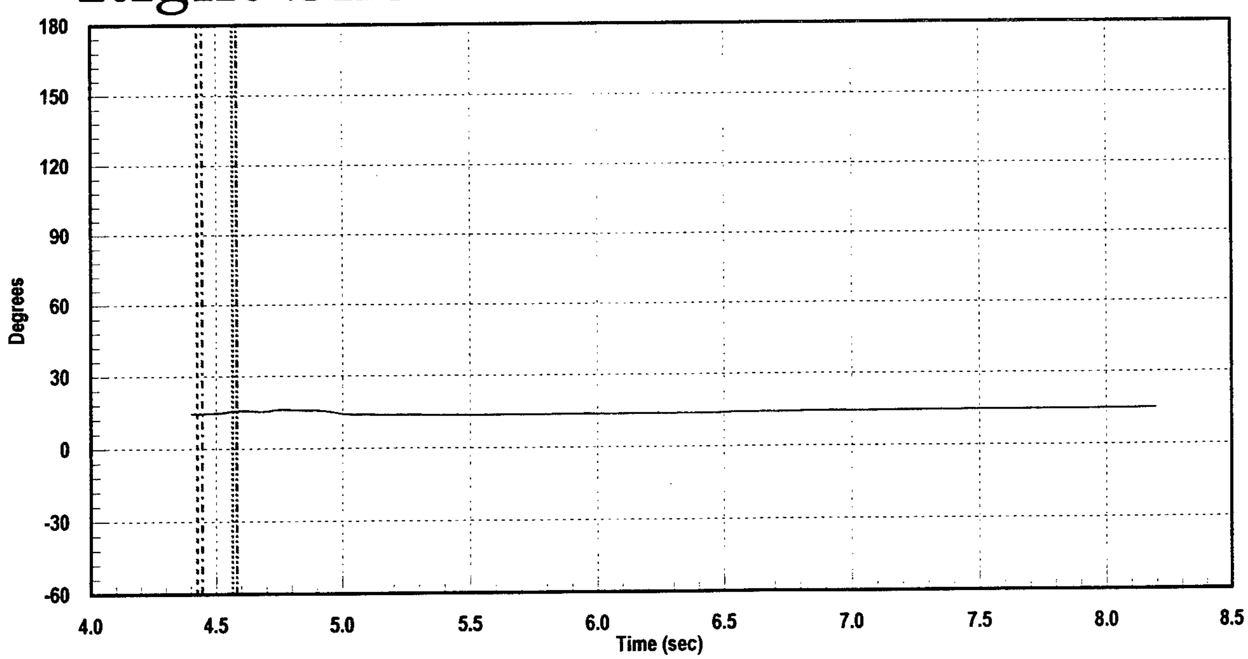
A-21

FL097516, 480 KEAS, 56,000 Ft

Left Shoulder Flexion/Extenstion

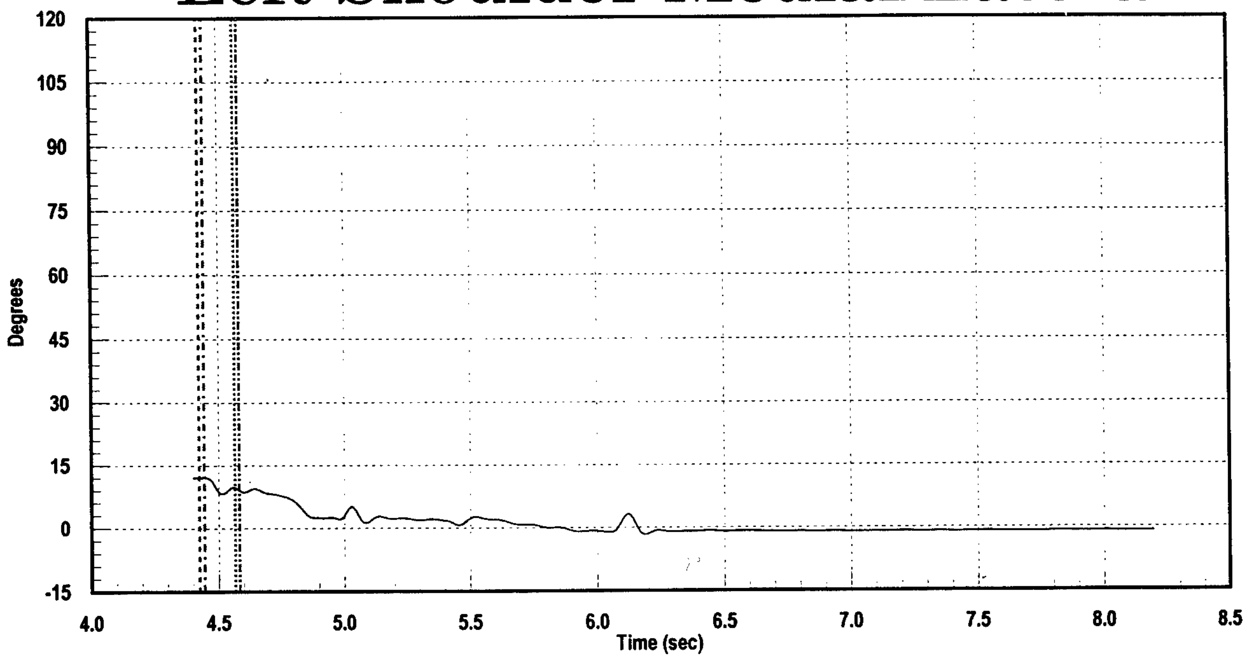


Right Shoulder Flexion/Extension

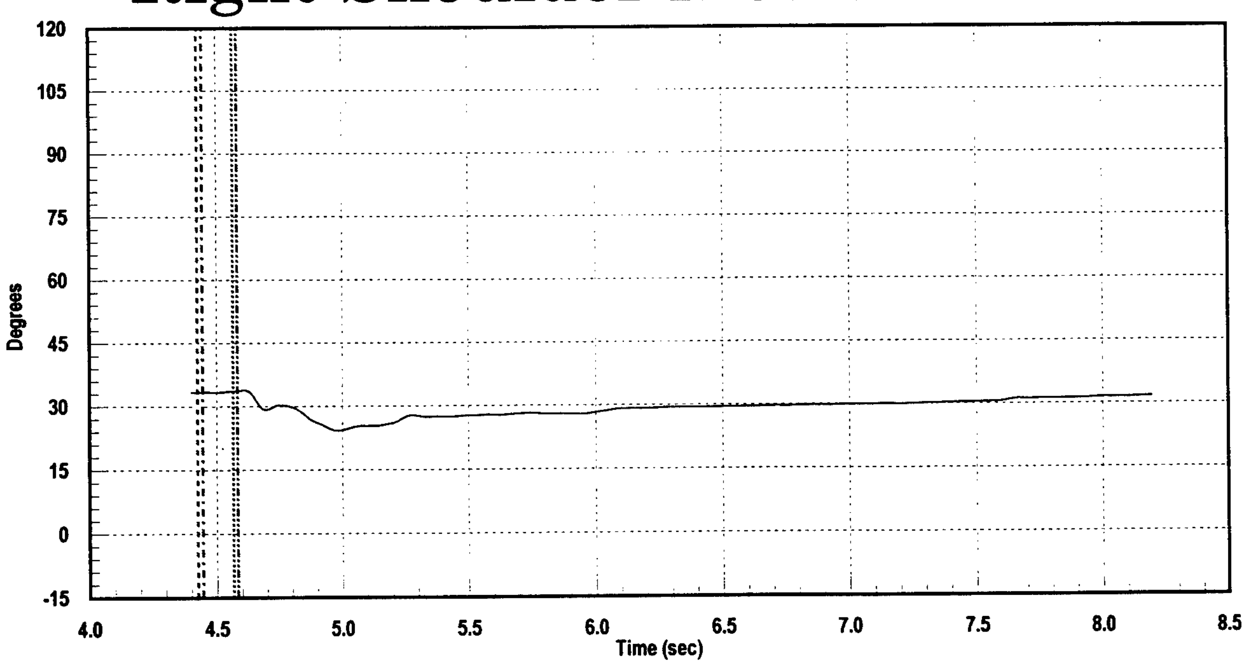


FL097516, 480 KEAS, 56,000 Ft

Left Shoulder Medial/Lateral



Right Shoulder Medial/Lateral



A-23

Appendix I

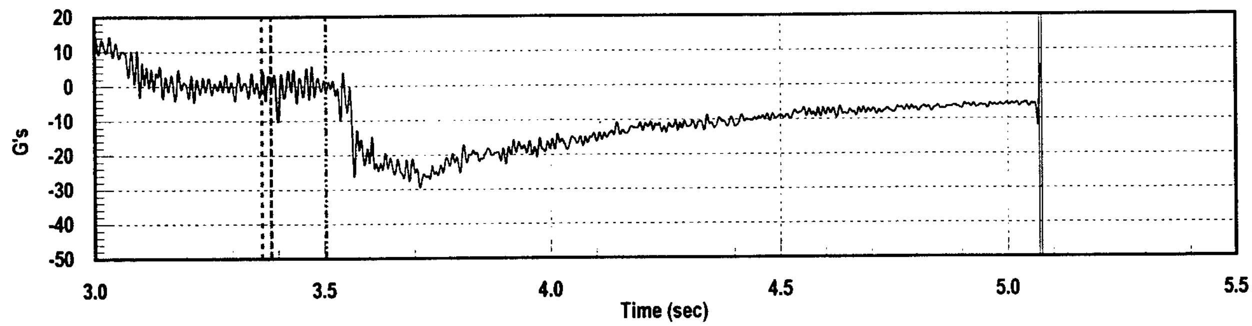
DR and Radical Output

SL1400, 730 KEAS
Dynamic Response Analysis

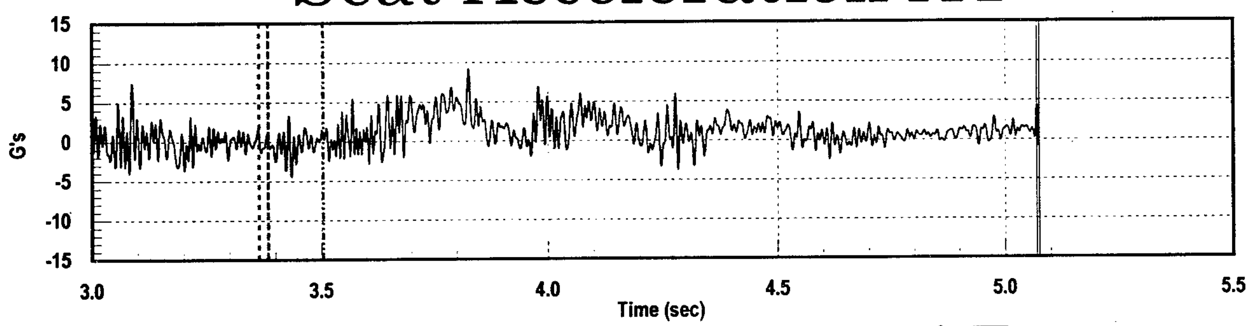
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

SL1400, 730 KEAS

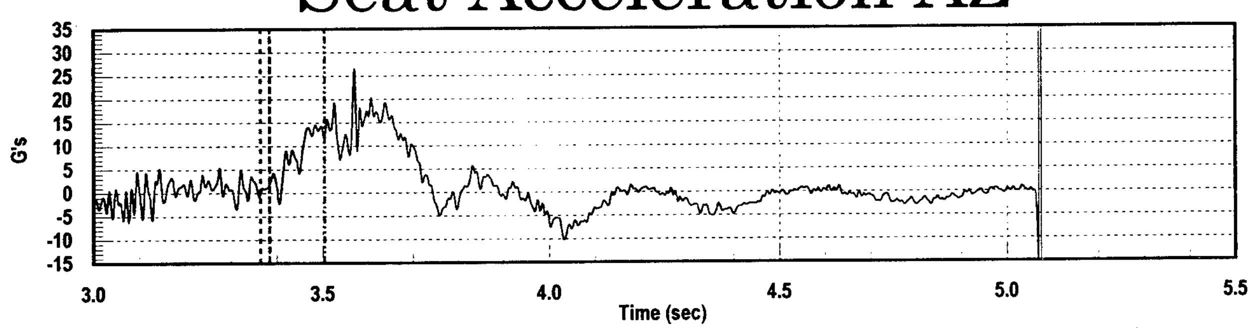
Seat Acceleration AX



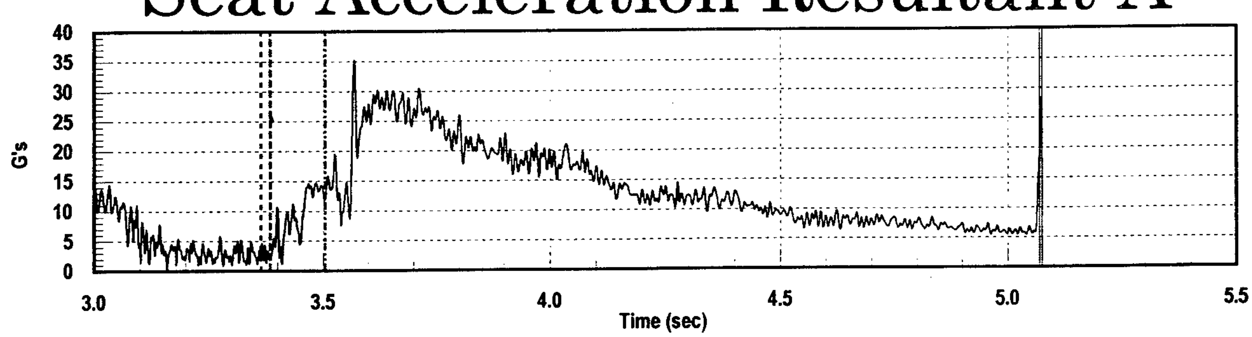
Seat Acceleration AY



Seat Acceleration AZ



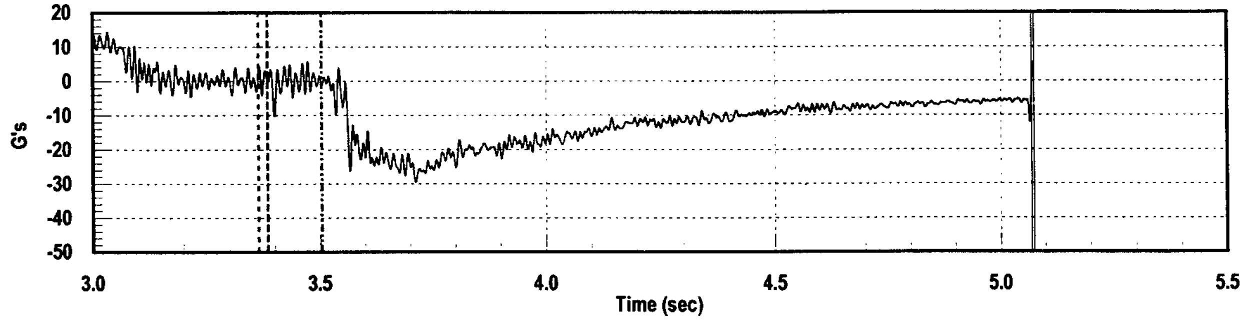
Seat Acceleration Resultant A



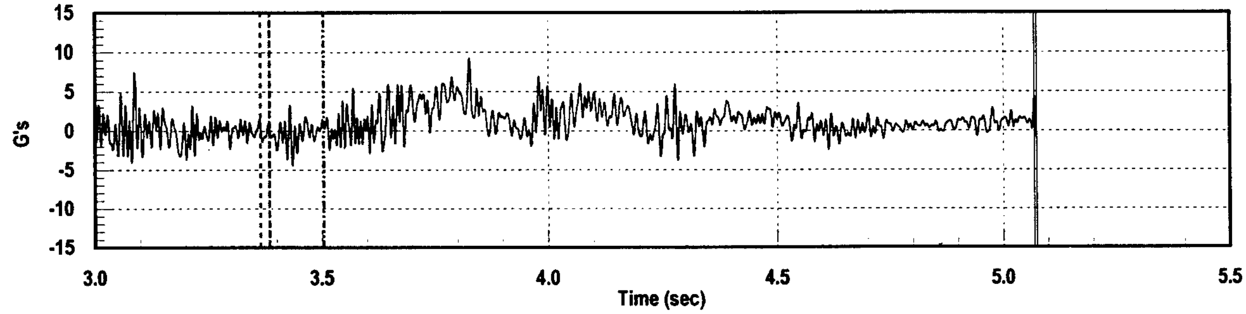
B-1

SL1400, 730 KEAS

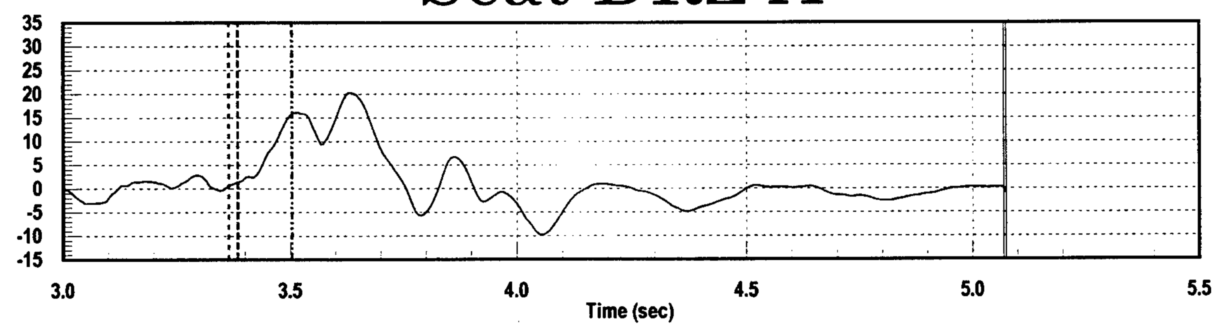
Seat Acceleration AX



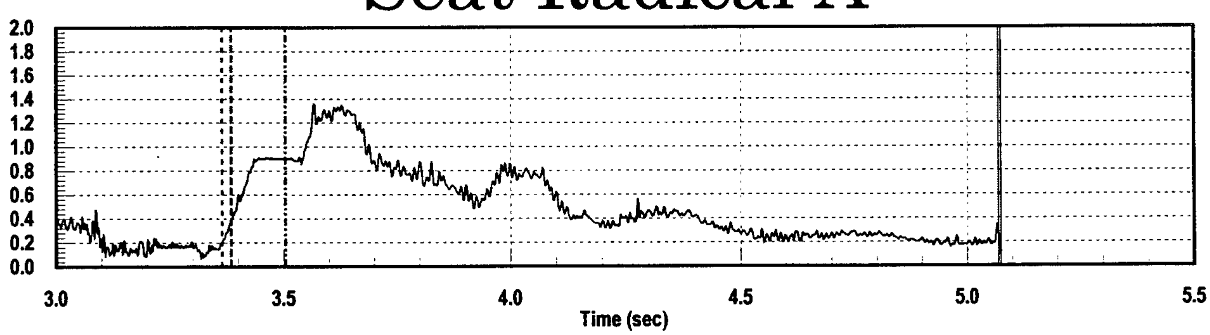
Seat Acceleration AY



Seat DRZ A



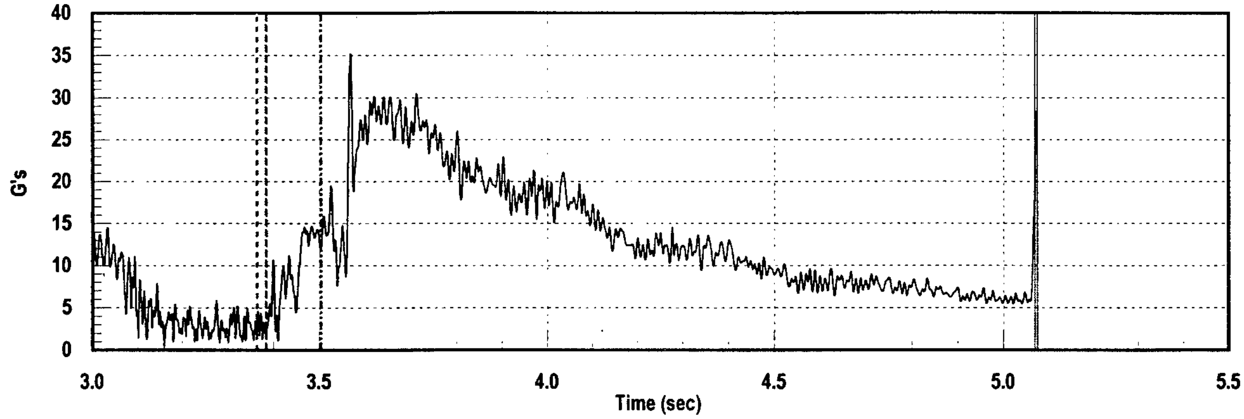
Seat Radical A



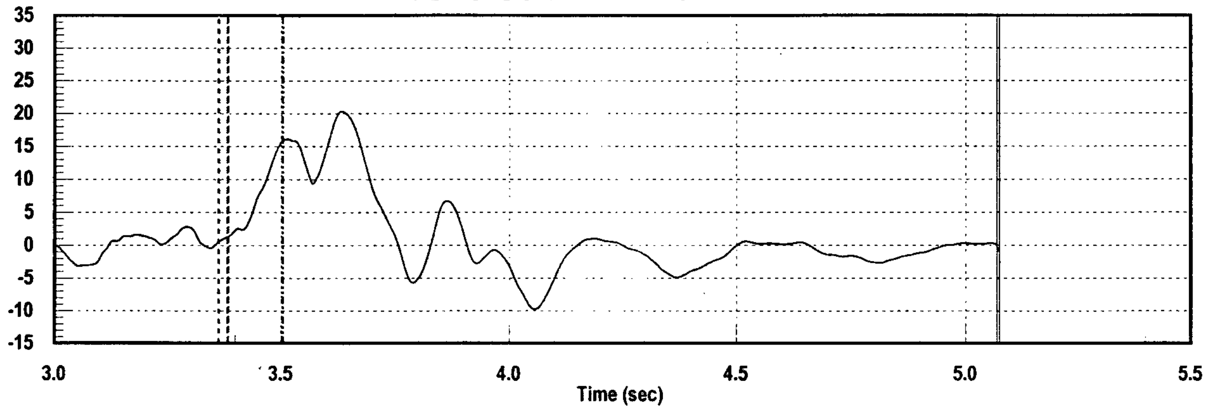
B-2

SL1400, 730 KEAS

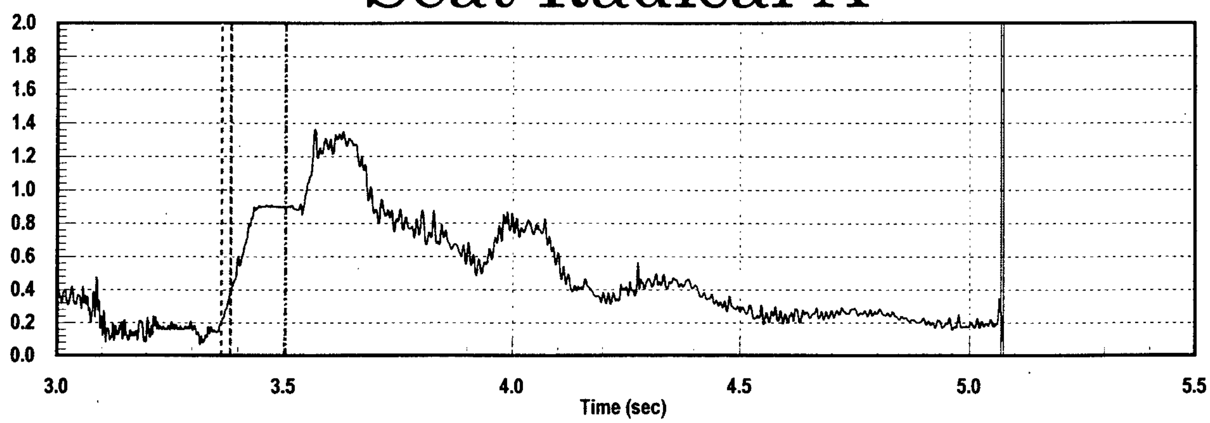
Seat Resultant A



Seat DRZ A

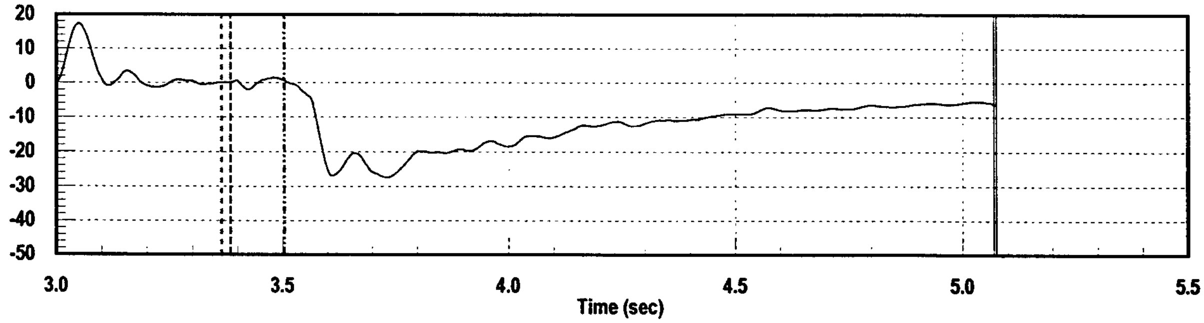


Seat Radical A

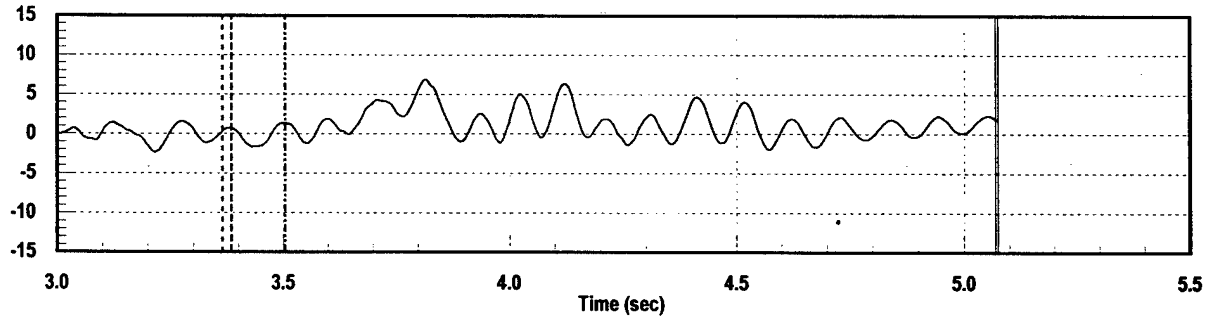


SL1400, 730 KEAS

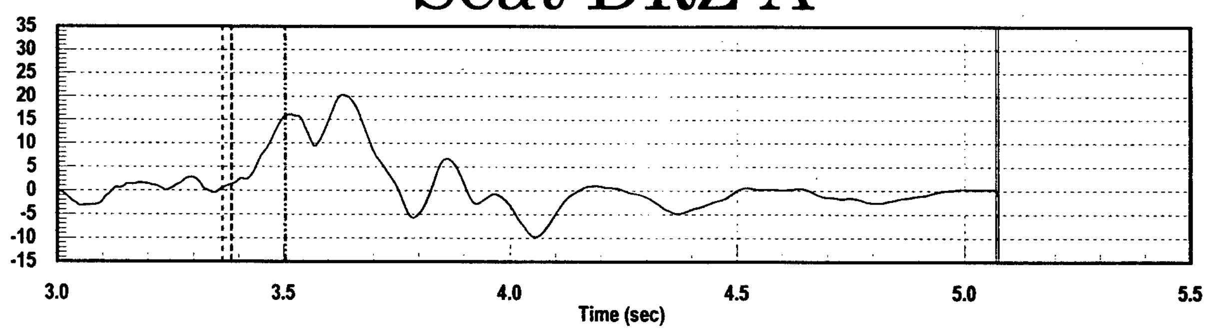
Seat DRX A



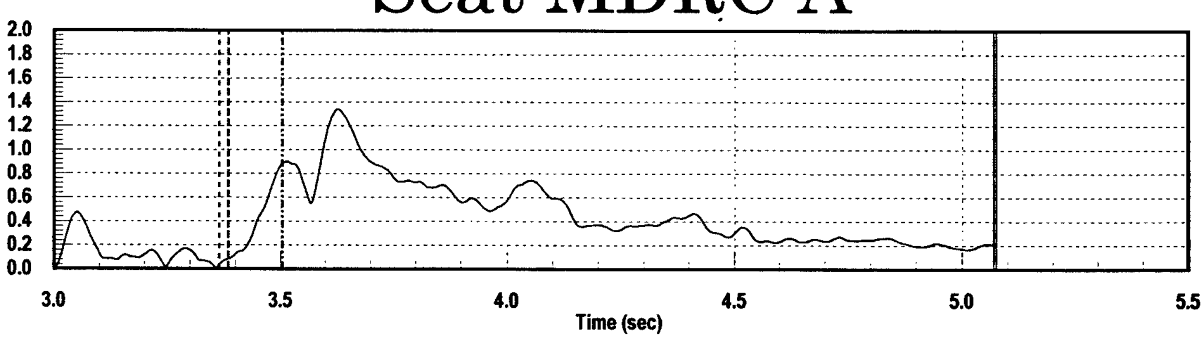
Seat DRY A



Seat DRZ A



Seat MDRC A



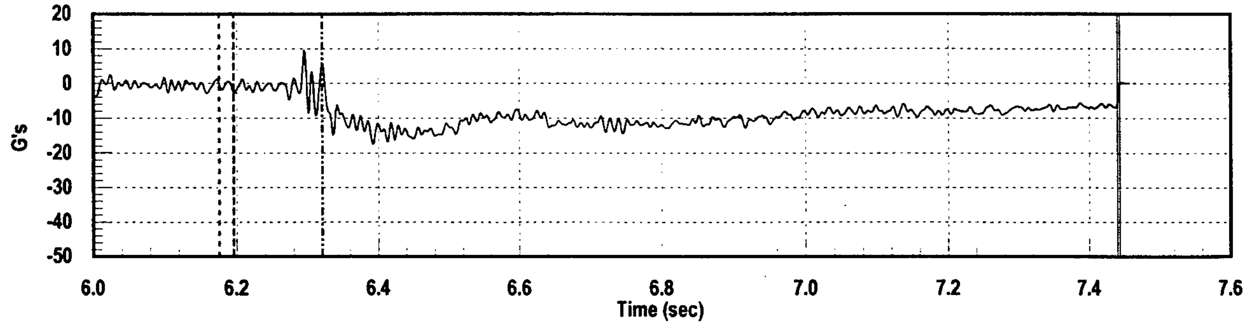
B-4

SL1050, 532 KEAS
Dynamic Response Analysis

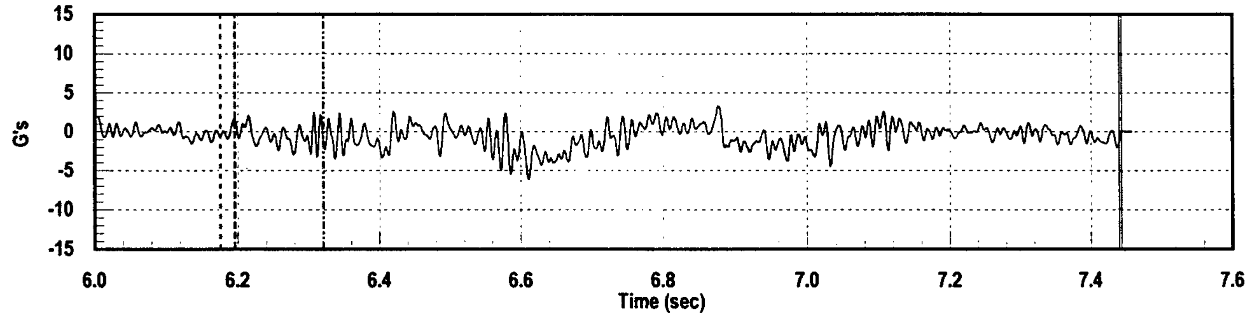
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

SL1050, 532 KEAS

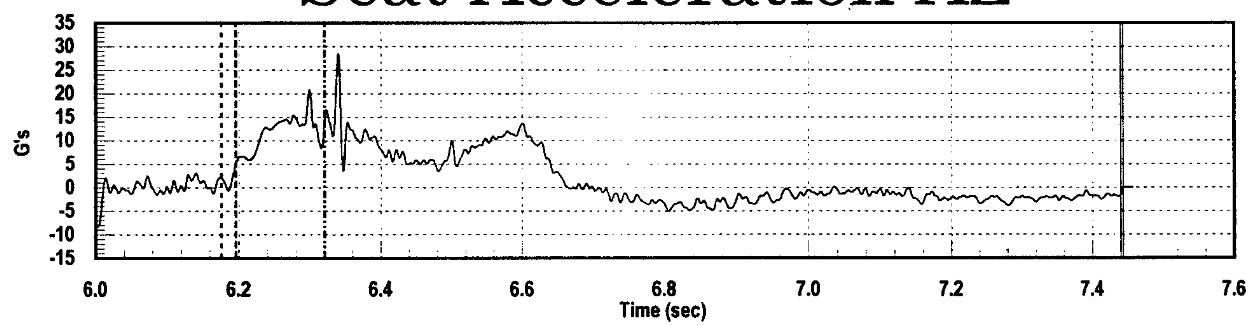
Seat Acceleration AX



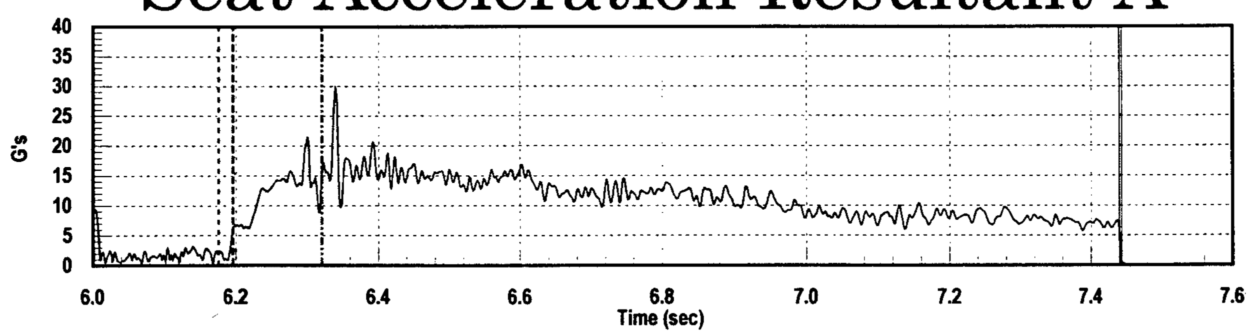
Seat Acceleration AY



Seat Acceleration AZ



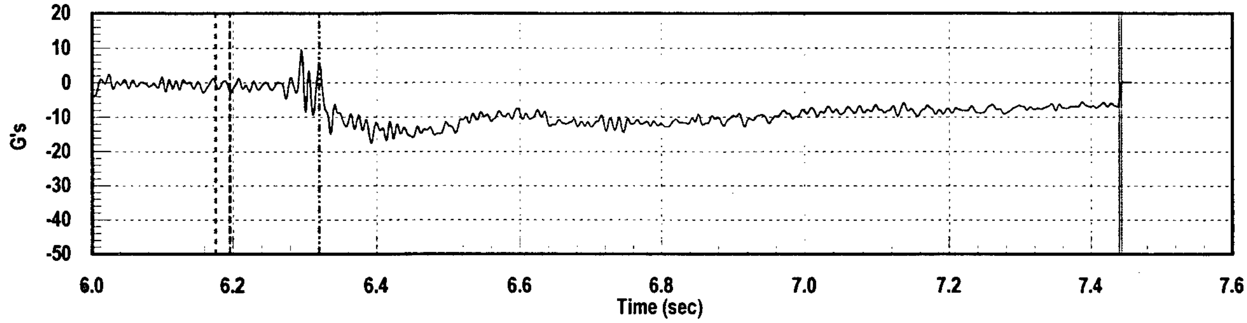
Seat Acceleration Resultant A



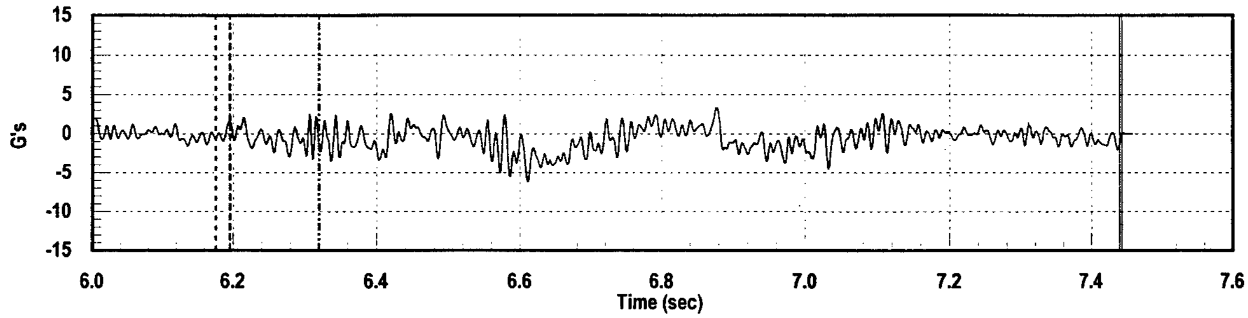
B-1

SL1050, 532 KEAS

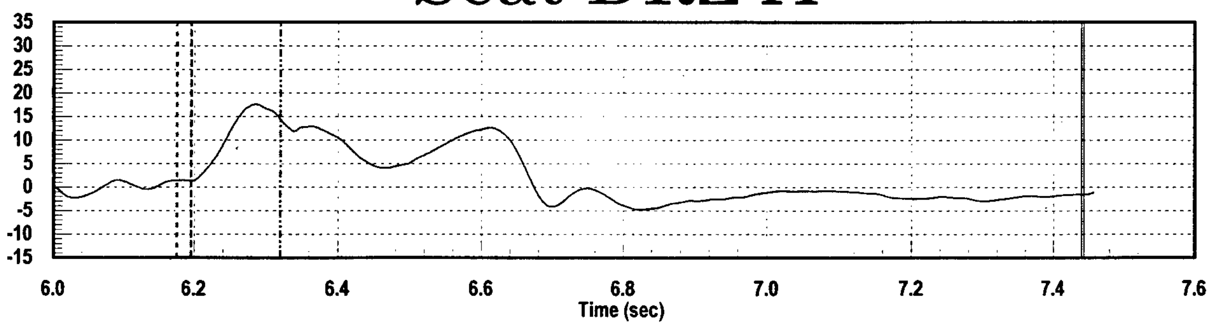
Seat Acceleration AX



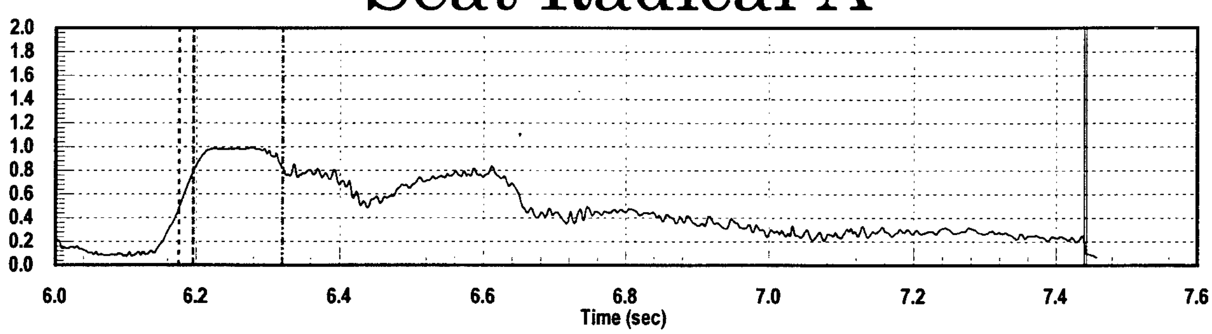
Seat Acceleration AY



Seat DRZ A



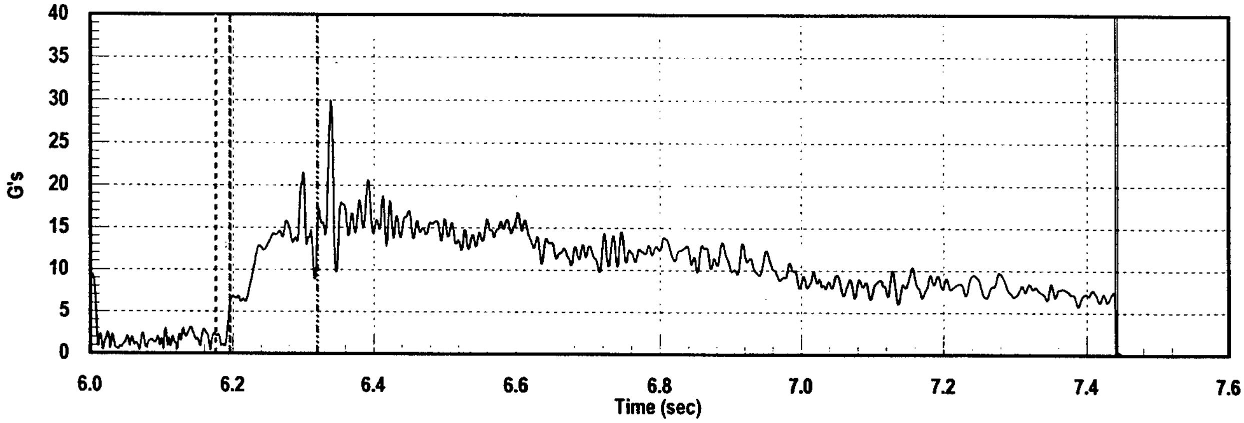
Seat Radical A



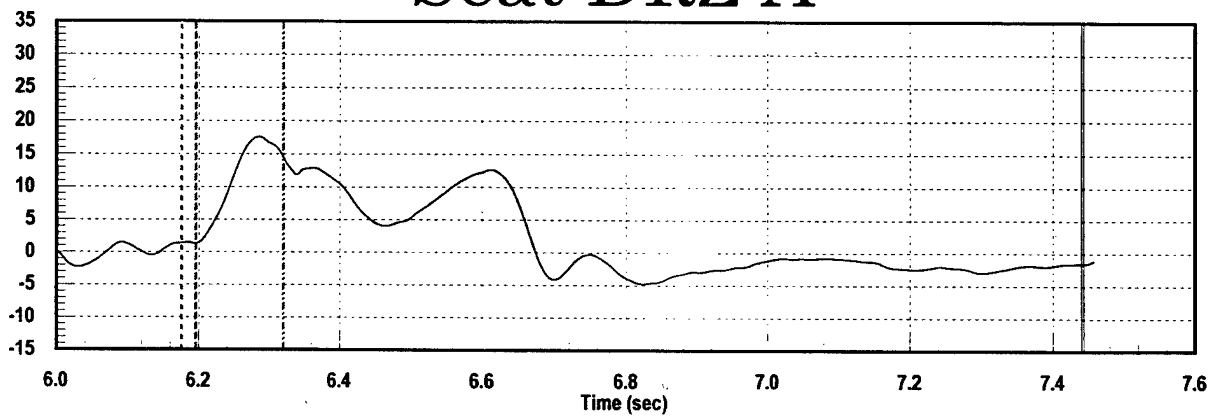
B-2

SL1050, 532 KEAS

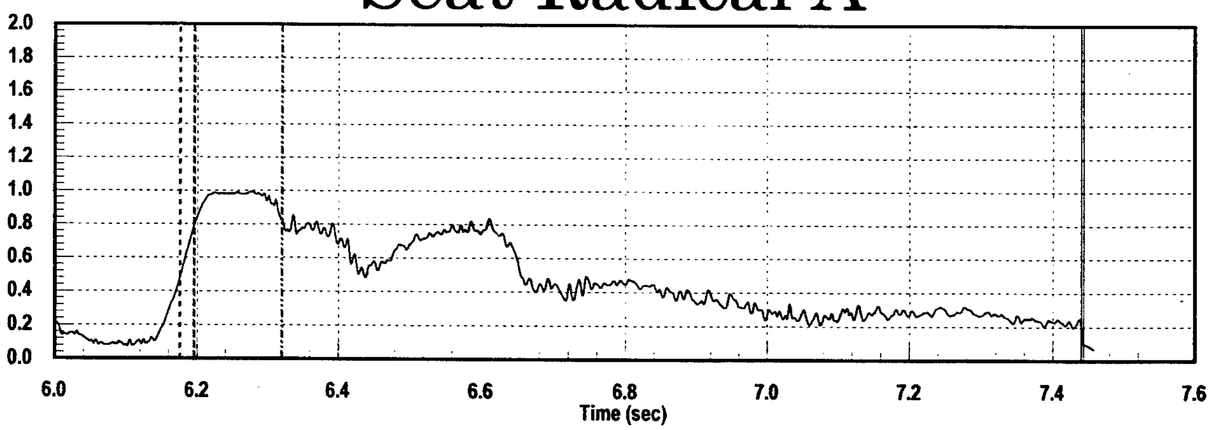
Seat Resultant A



Seat DRZ A



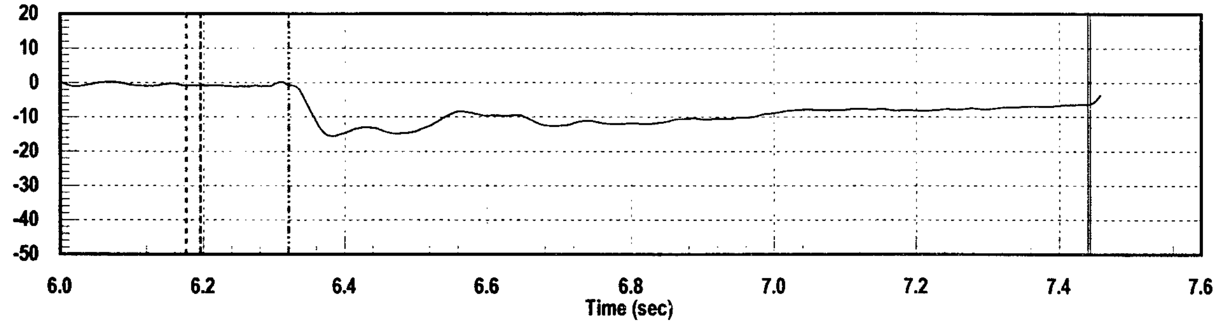
Seat Radical A



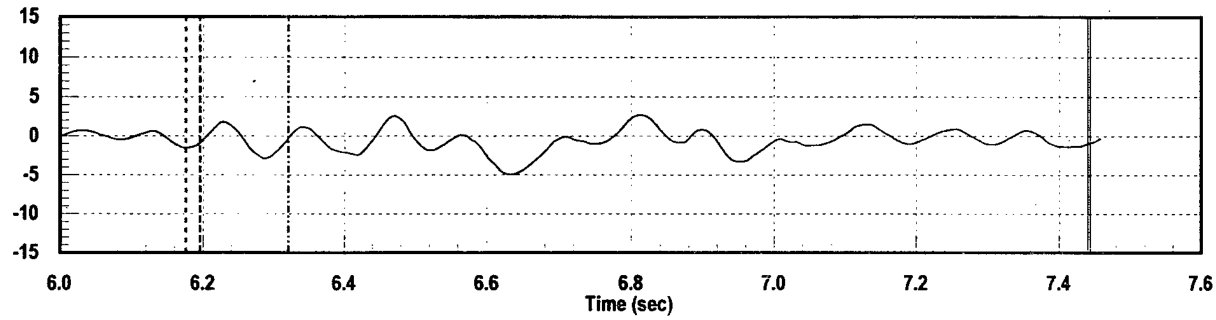
B-3

SL1050, 532 KEAS

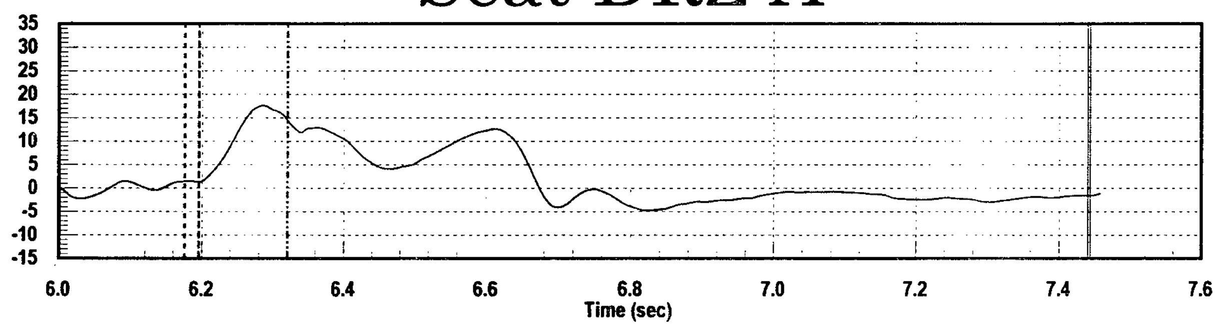
Seat DRX A



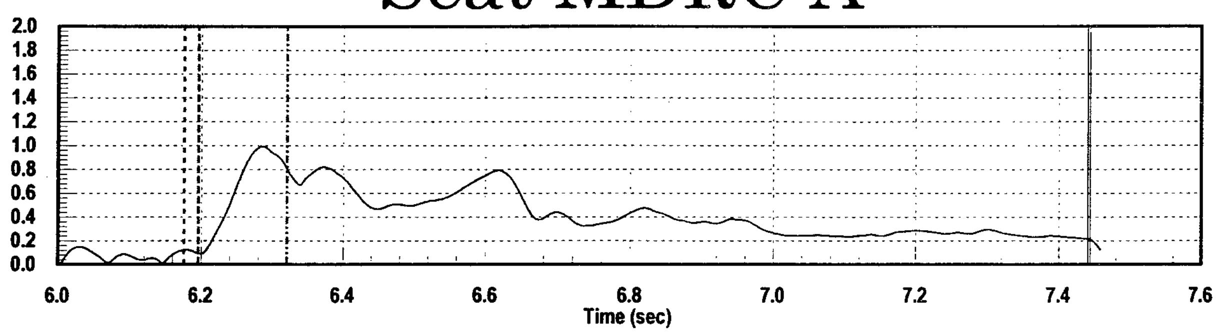
Seat DRY A



Seat DRZ A



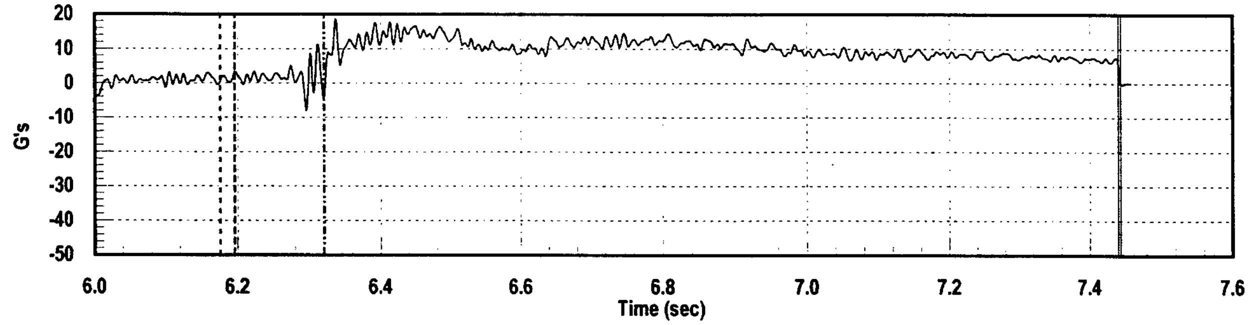
Seat MDRC A



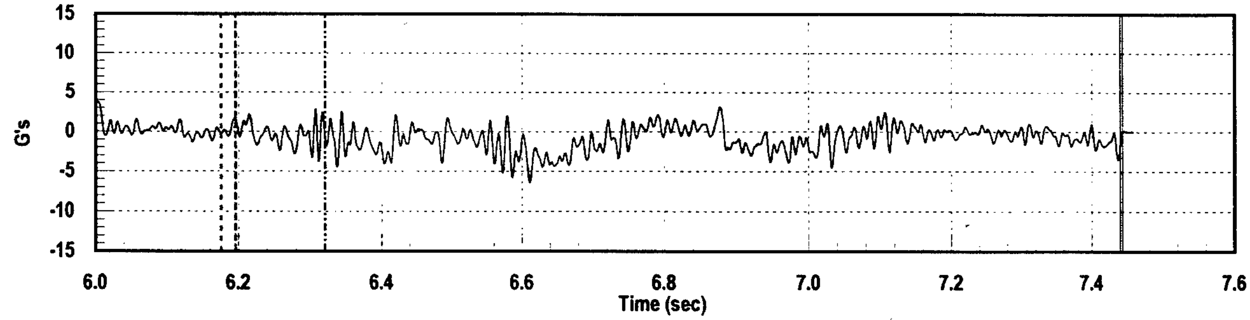
B-4

SL1050, 532 KEAS

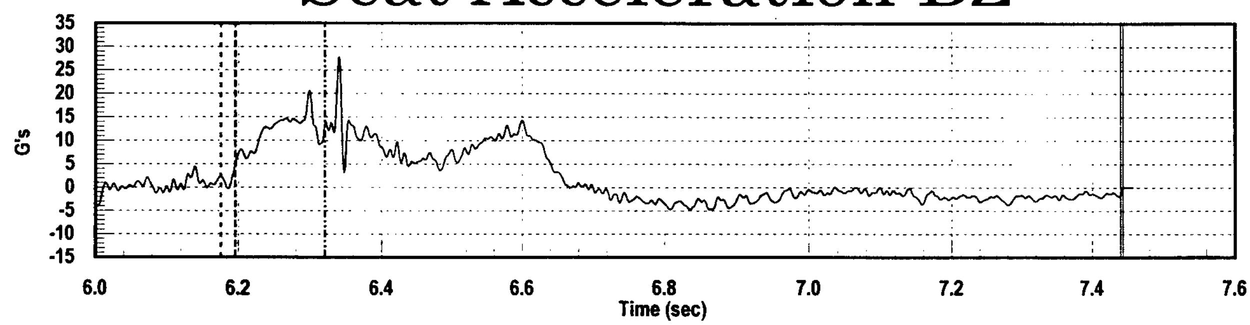
Seat Acceleration BX



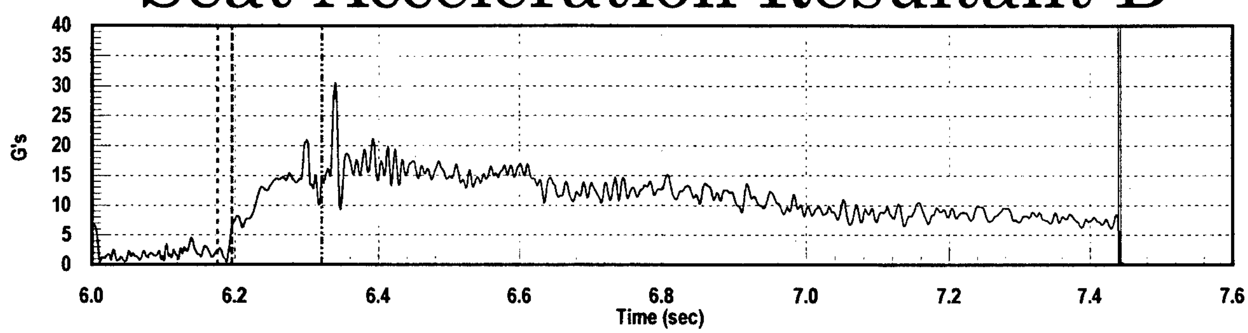
Seat Acceleration BY



Seat Acceleration BZ

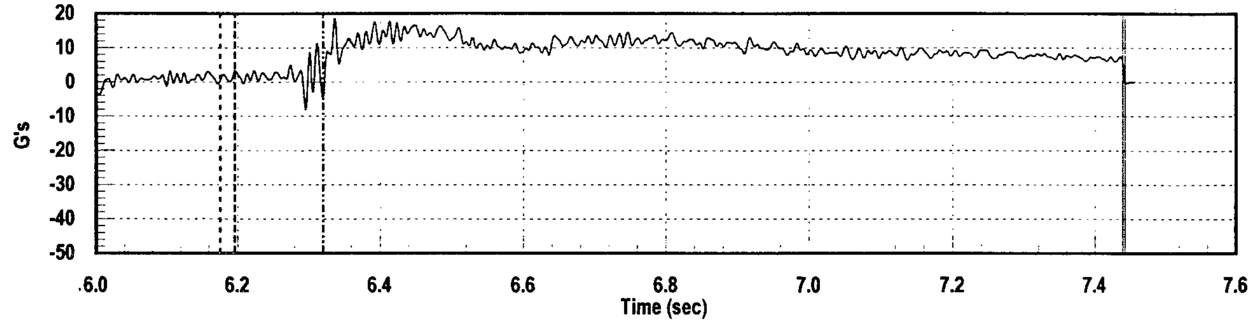


Seat Acceleration Resultant B

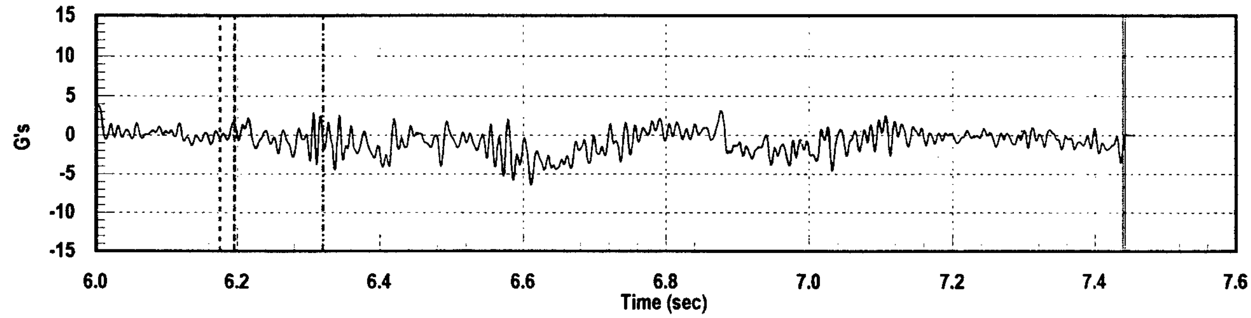


SL1050, 532 KEAS

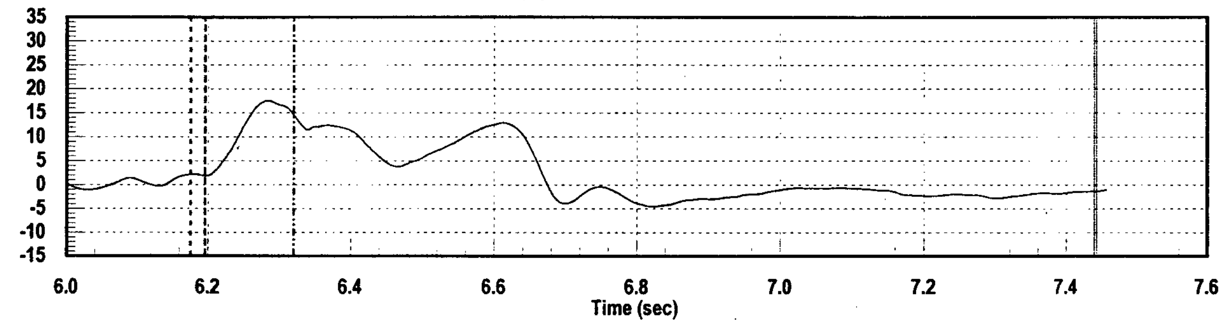
Seat Acceleration BX



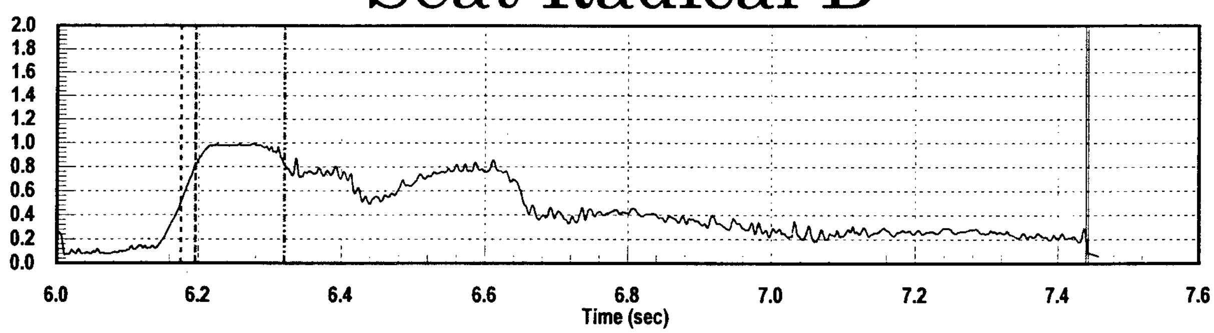
Seat Acceleration BY



Seat DRZ B



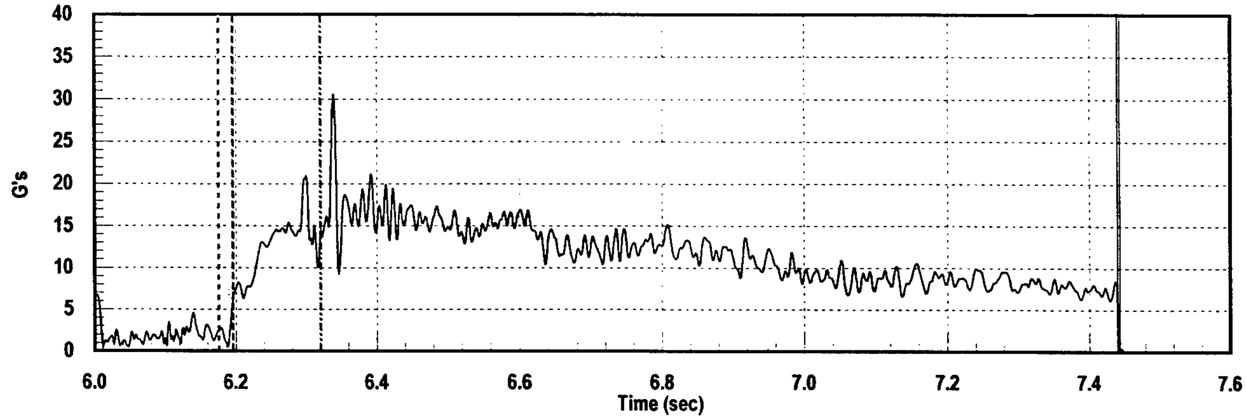
Seat Radical B



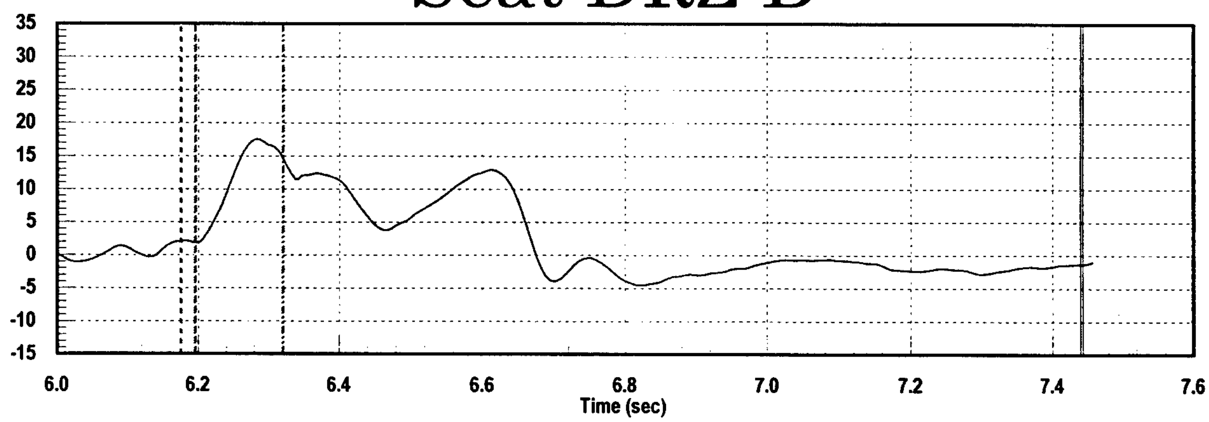
B-6

SL1050, 532 KEAS

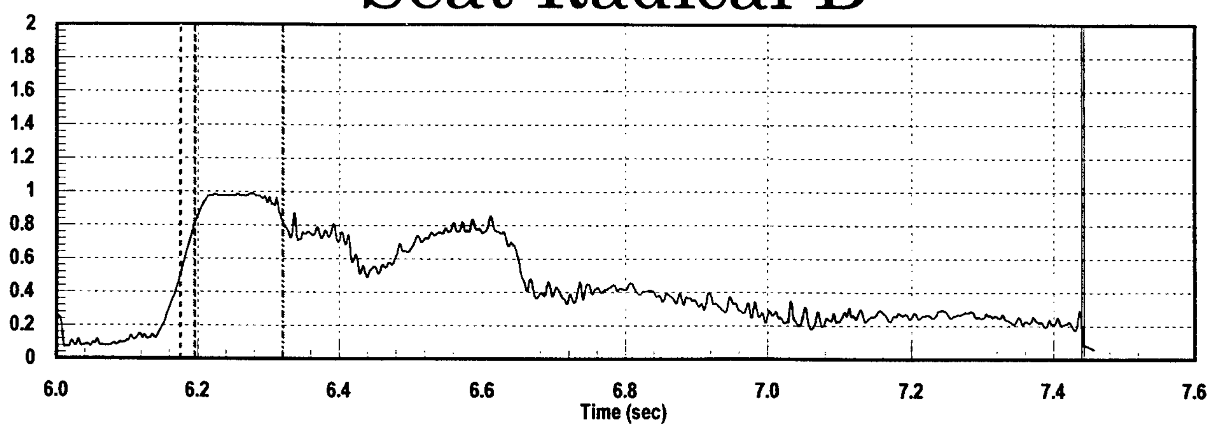
Seat Resultant B



Seat DRZ B



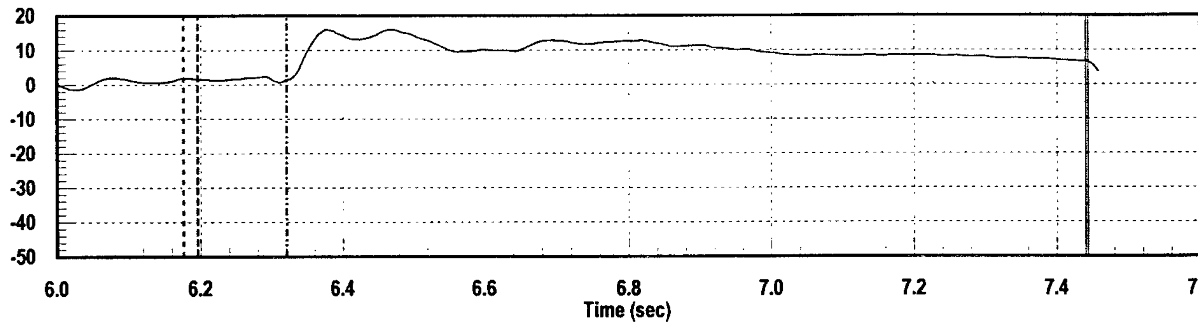
Seat Radical B



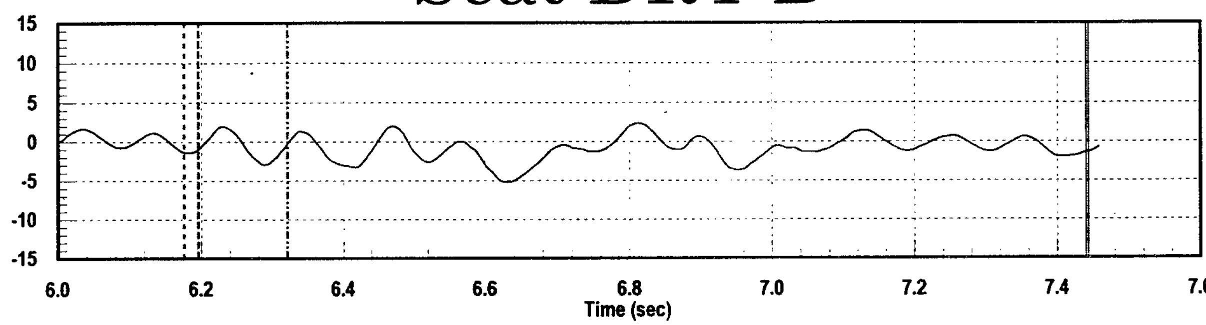
B-7

SL1050, 532 KEAS

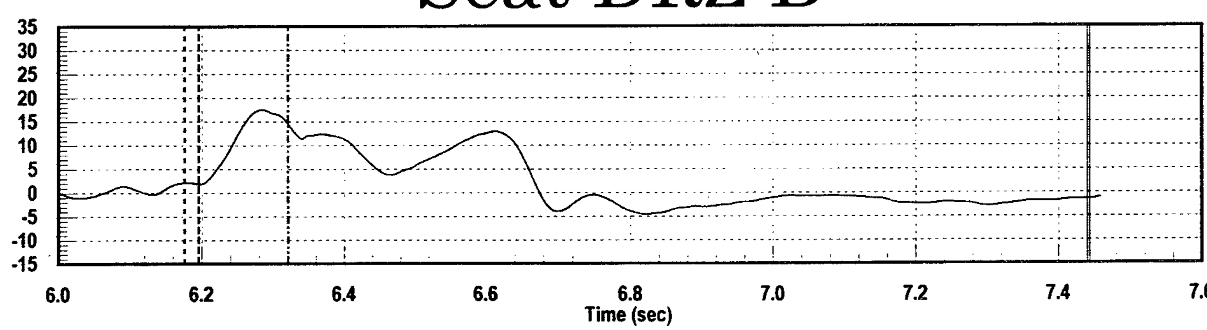
Seat DRX B



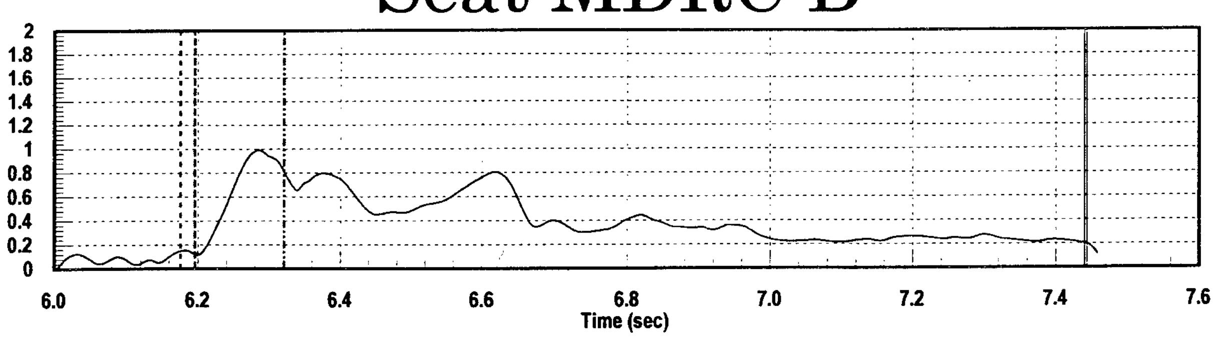
Seat DRY B



Seat DRZ B



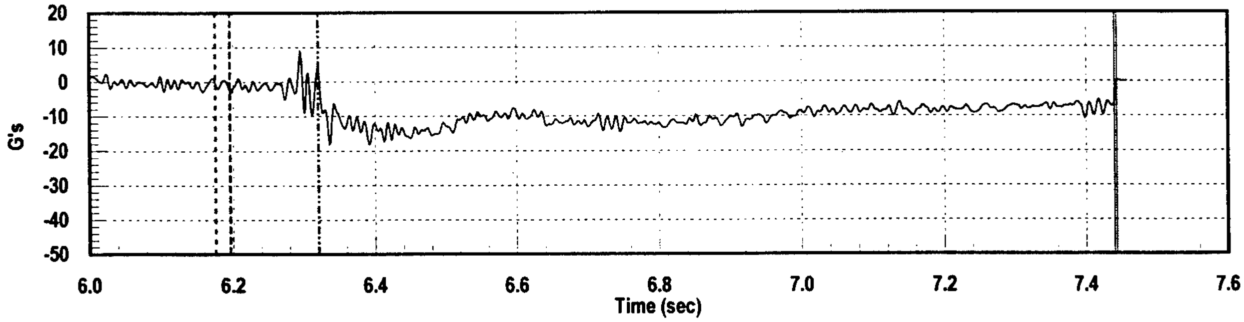
Seat MDRC B



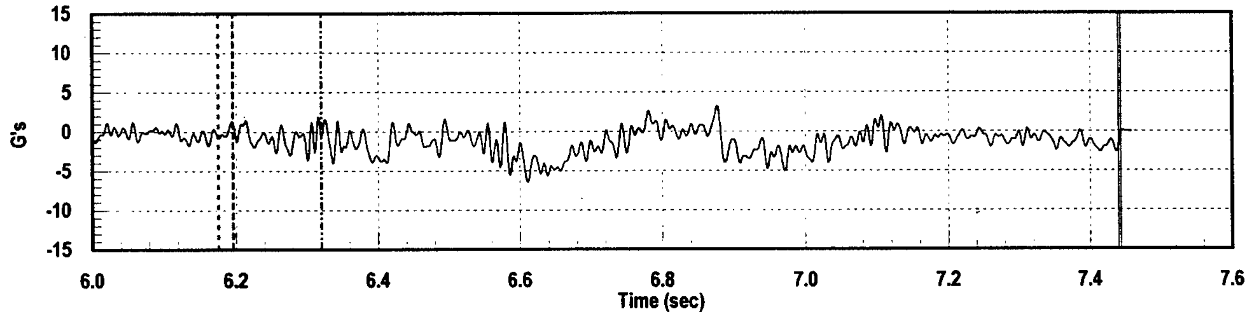
B-8

SL1050, 532 KEAS

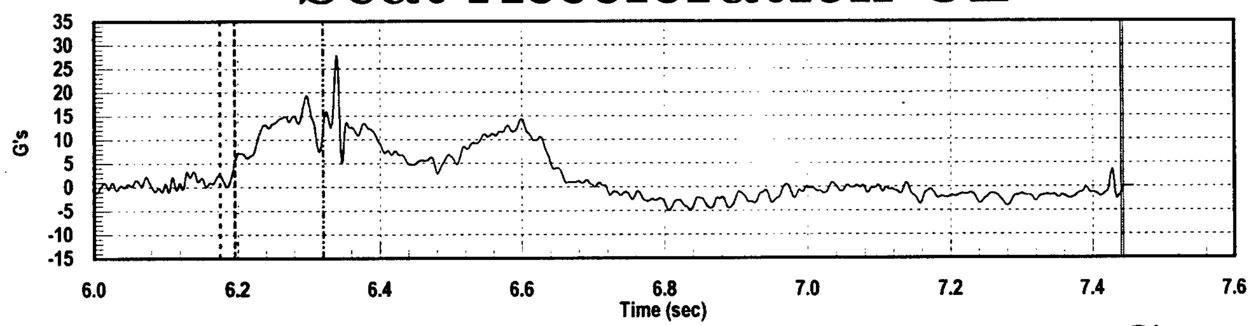
Seat Acceleration CX



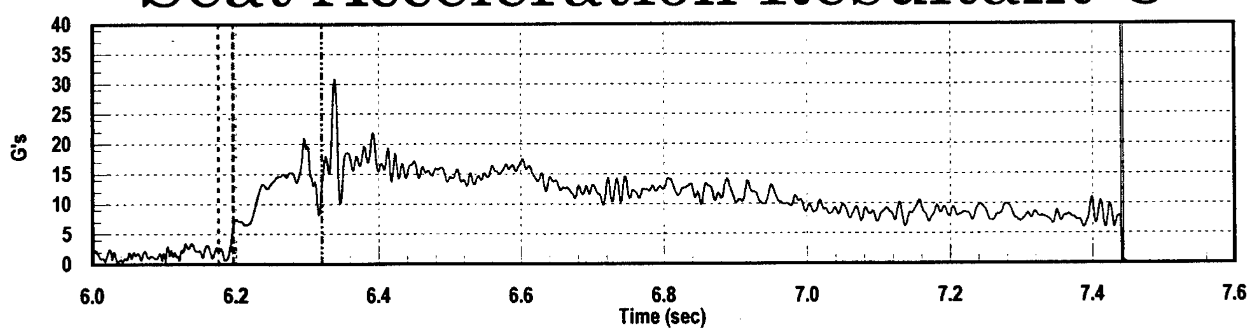
Seat Acceleration CY



Seat Acceleration CZ



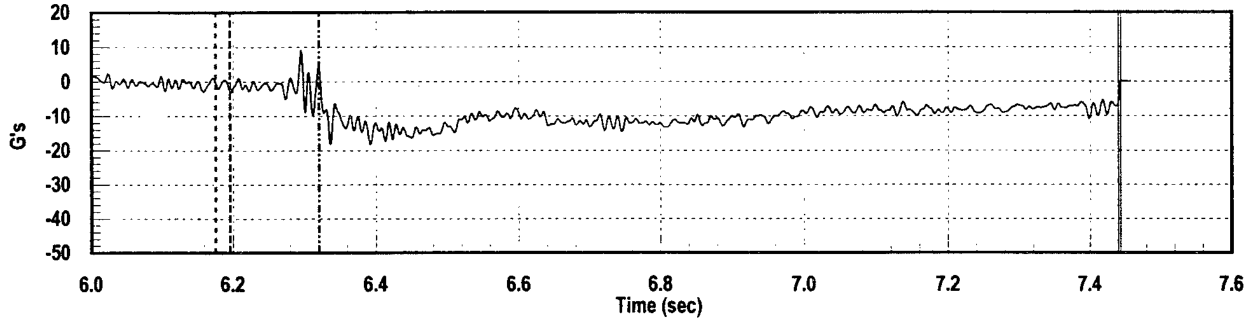
Seat Acceleration Resultant C



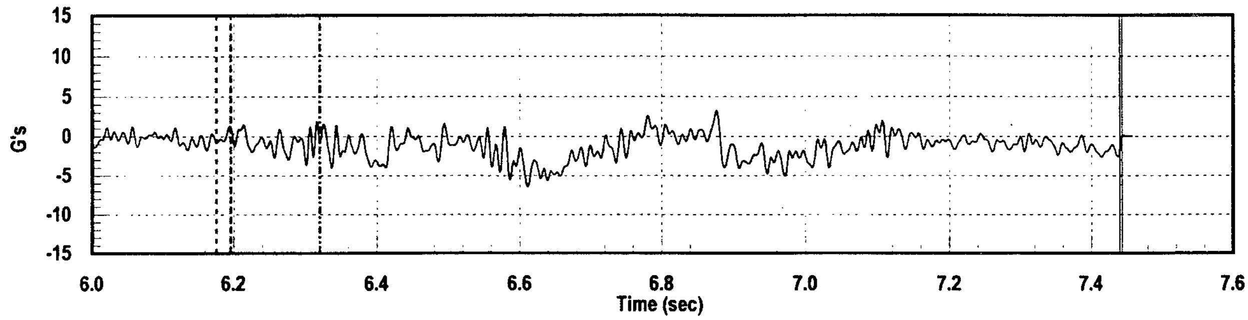
B-9

SL1050, 532 KEAS

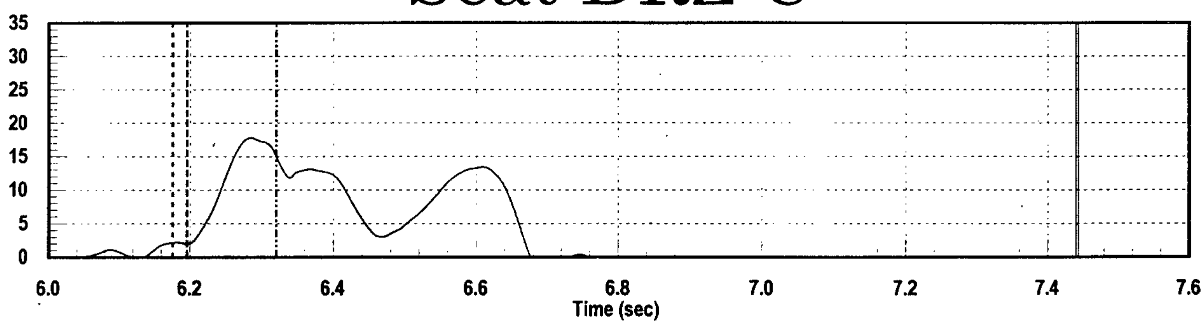
Seat Acceleration CX



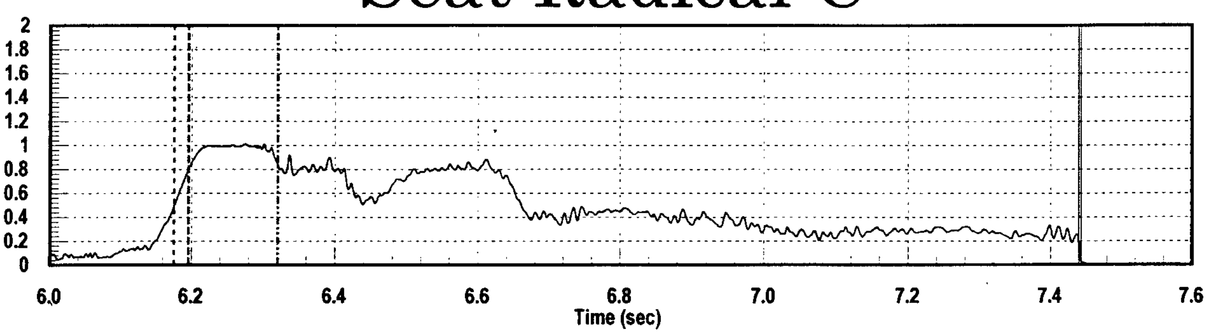
Seat Acceleration CY



Seat DRZ C



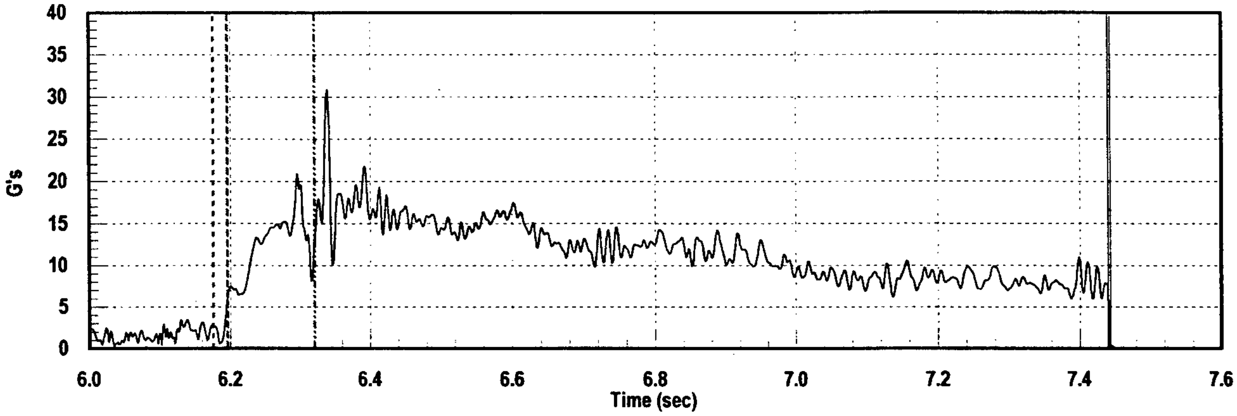
Seat Radical C



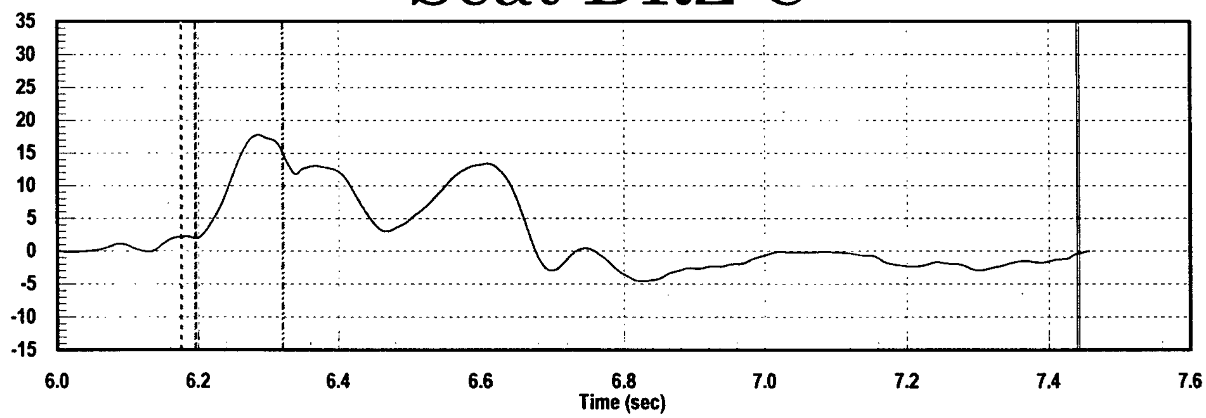
B-10

SL1050, 532 KEAS

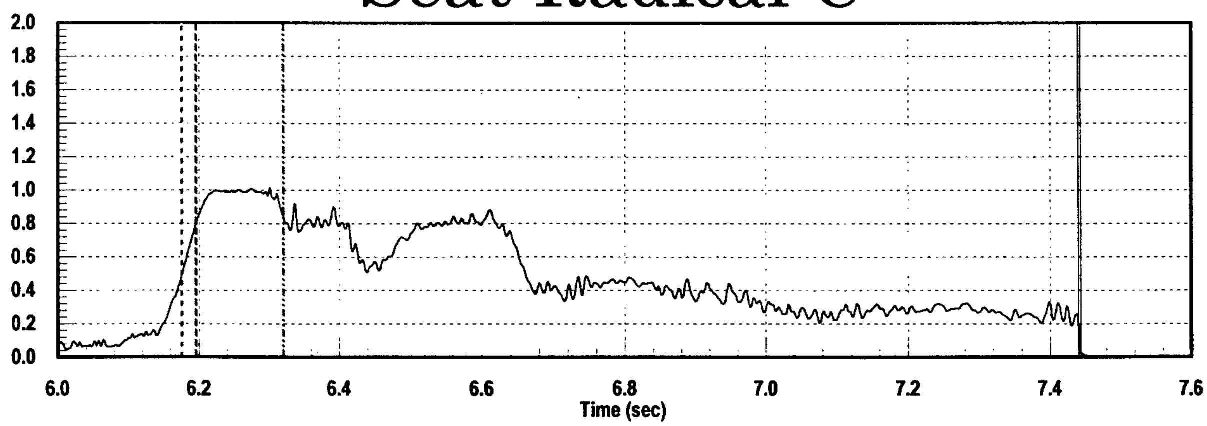
Seat Resultant C



Seat DRZ C



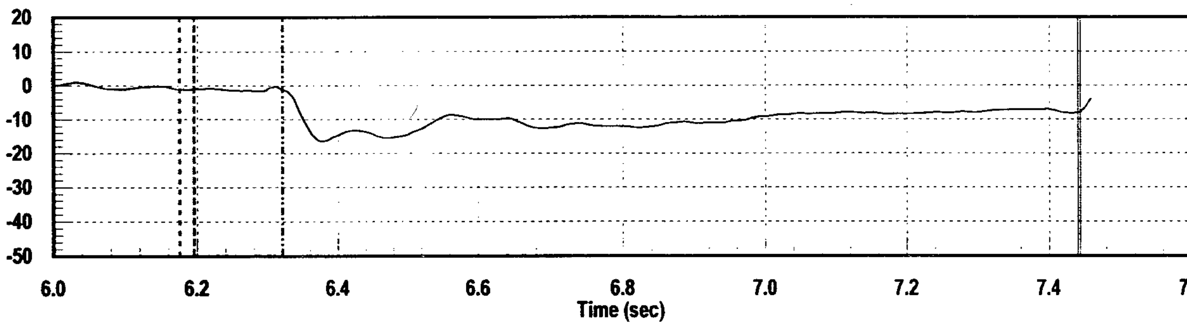
Seat Radical C



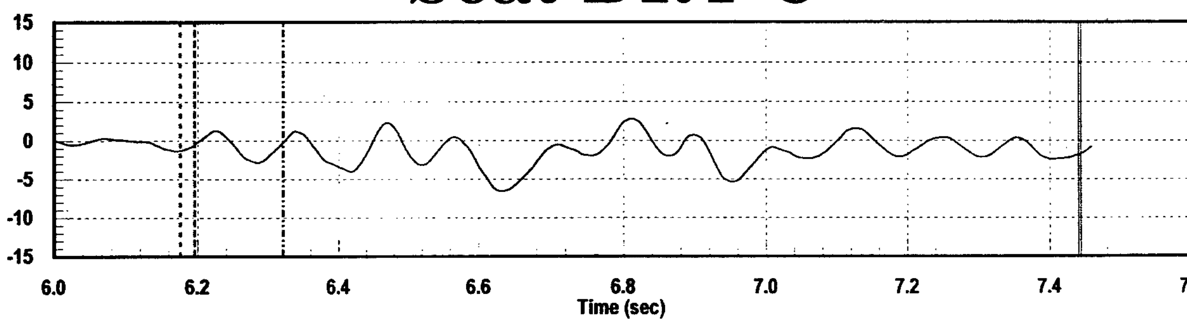
B-11

SL1050, 532 KEAS

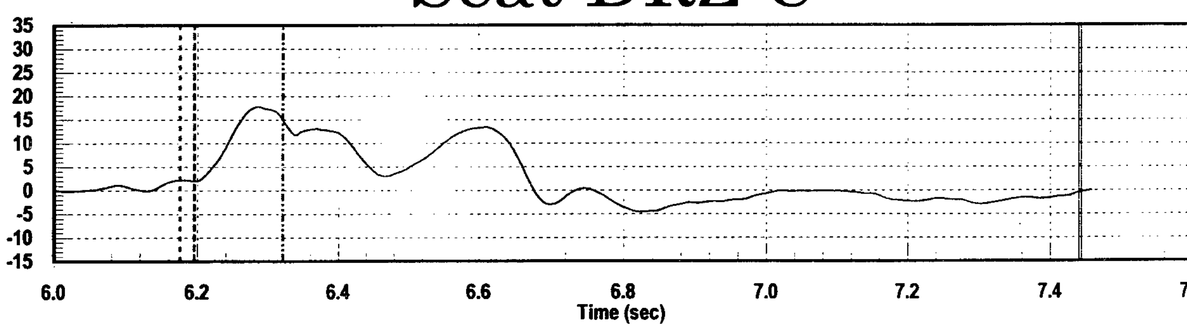
Seat DRX C



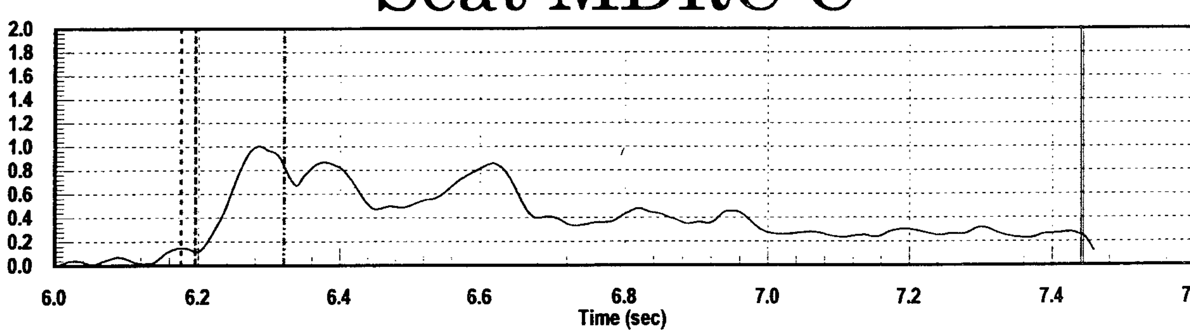
Seat DRY C



Seat DRZ C



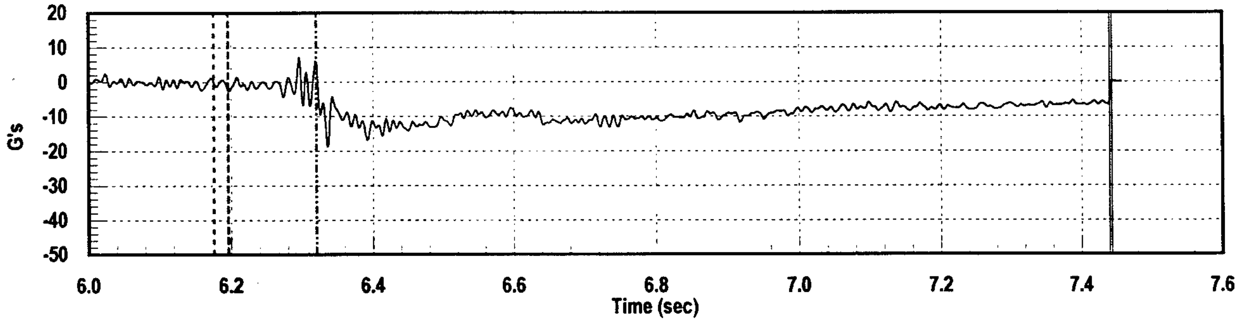
Seat MDRC C



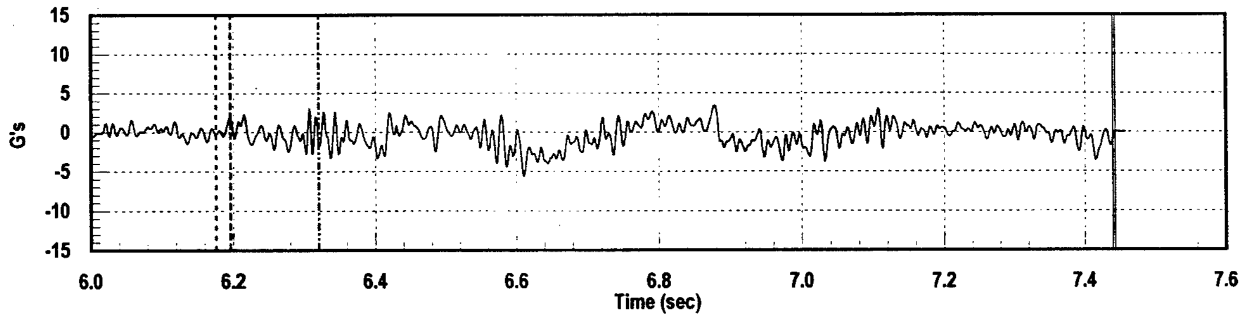
B-12

SL1050, 532 KEAS

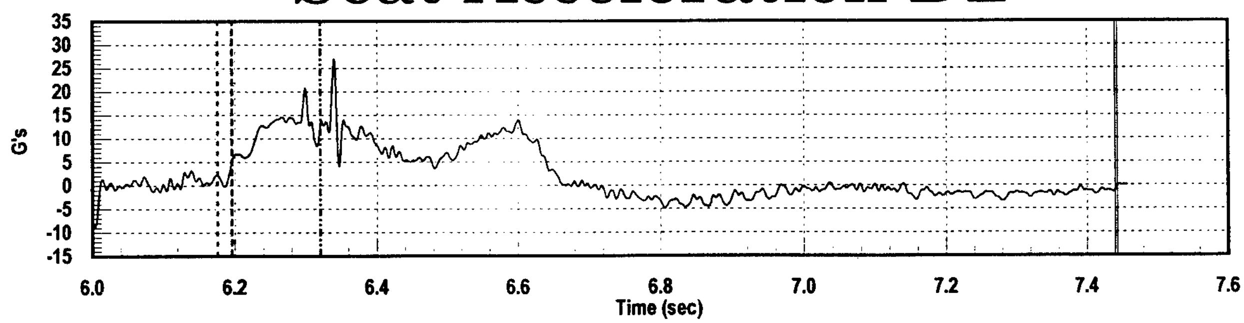
Seat Acceleration DX



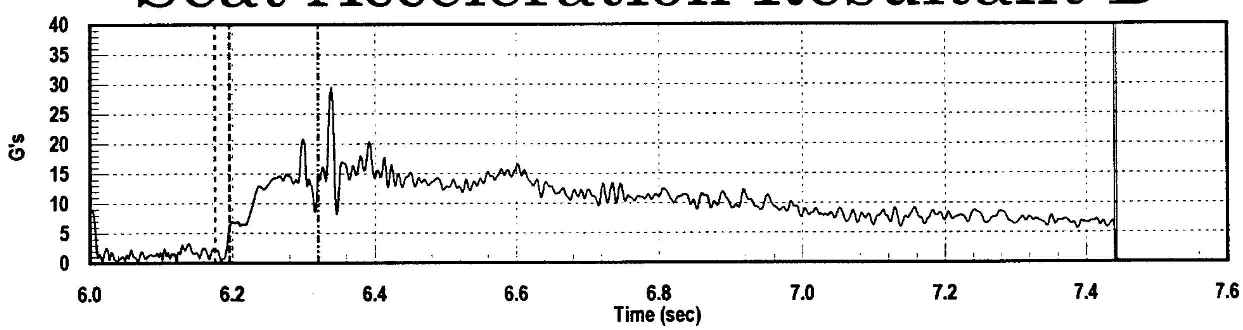
Seat Acceleration DY



Seat Acceleration DZ

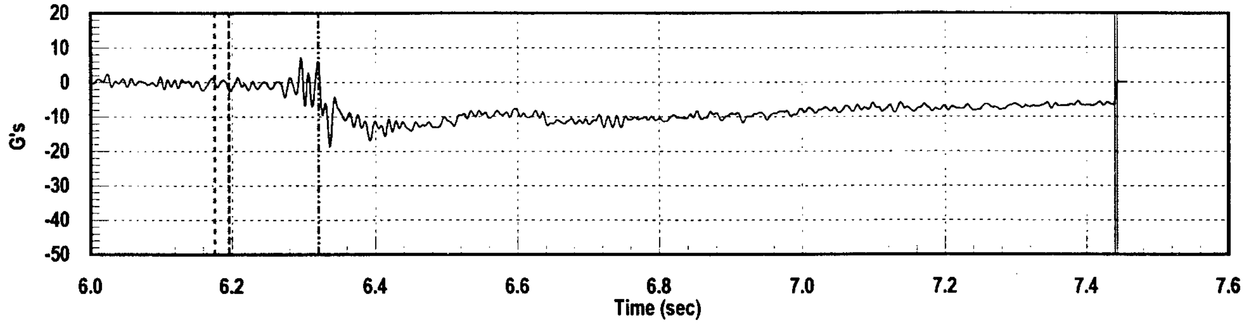


Seat Acceleration Resultant D

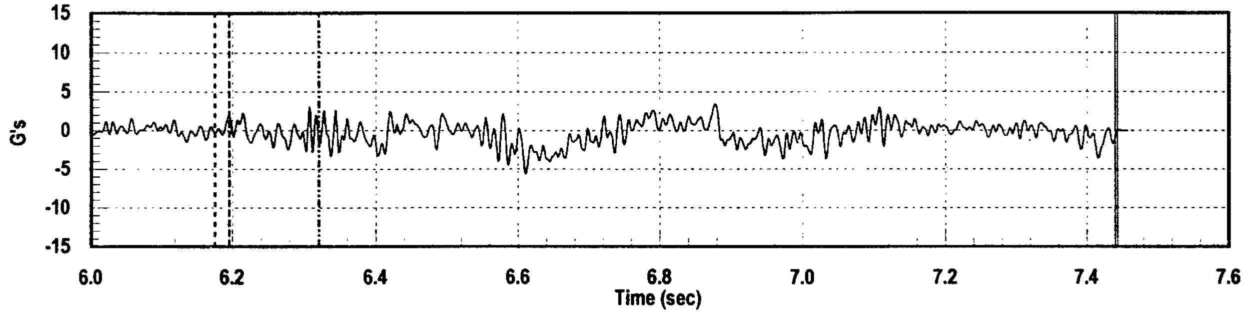


SL1050, 532 KEAS

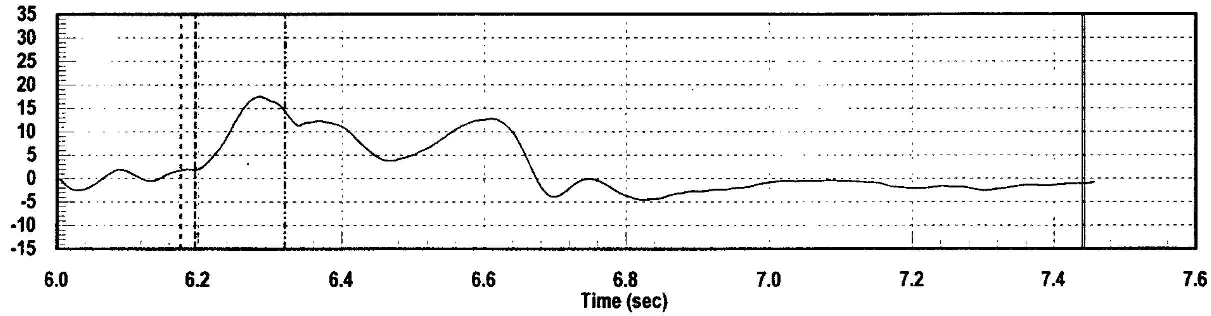
Seat Acceleration DX



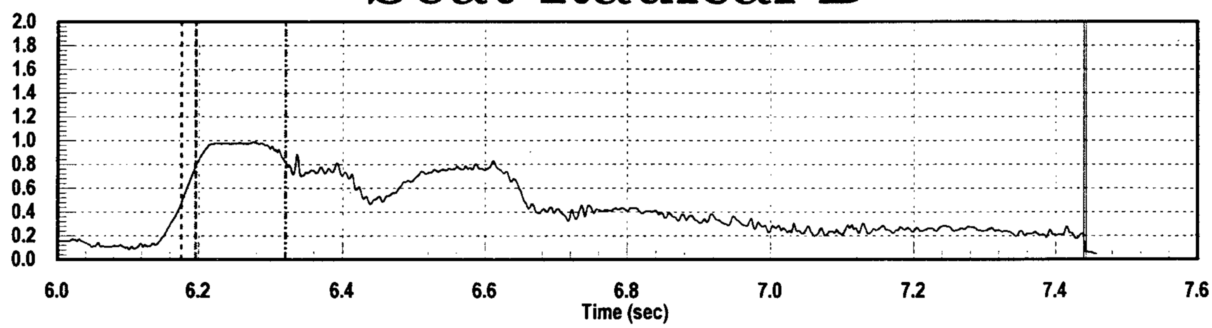
Seat Acceleration DY



Seat DRZ D

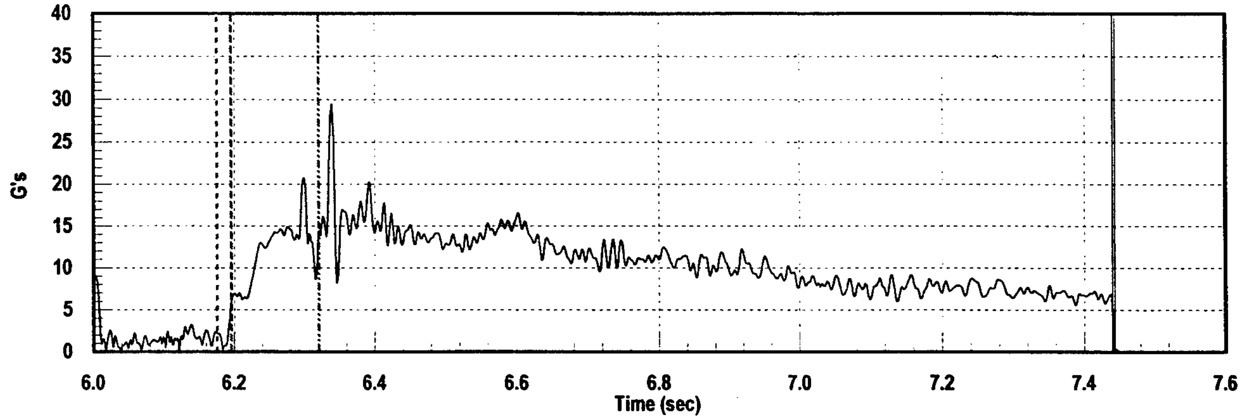


Seat Radical D

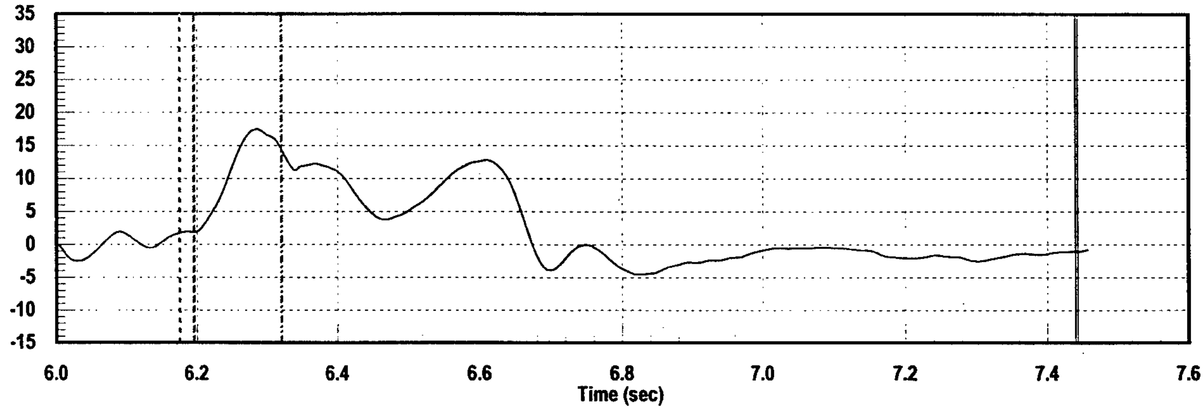


SL1050, 532 KEAS

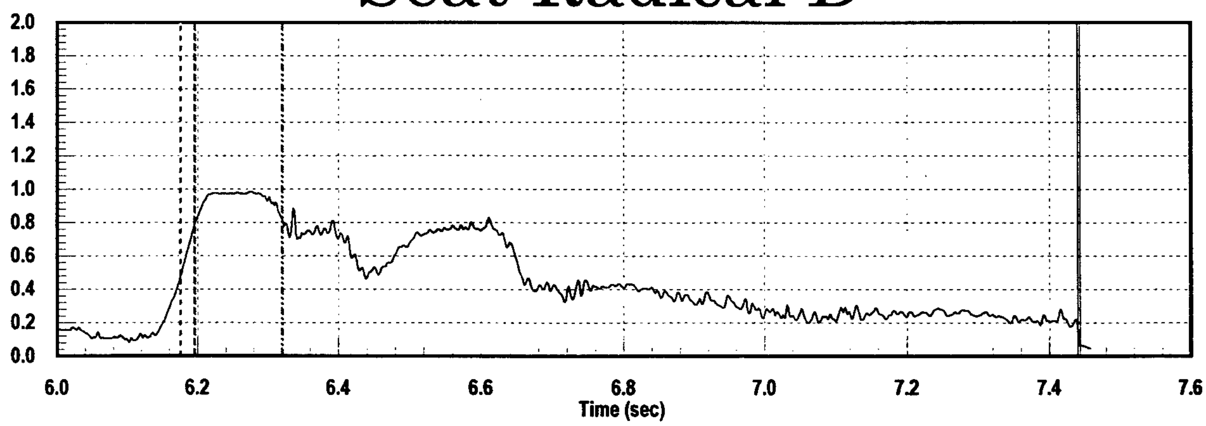
Seat Resultant D



Seat DRZ D

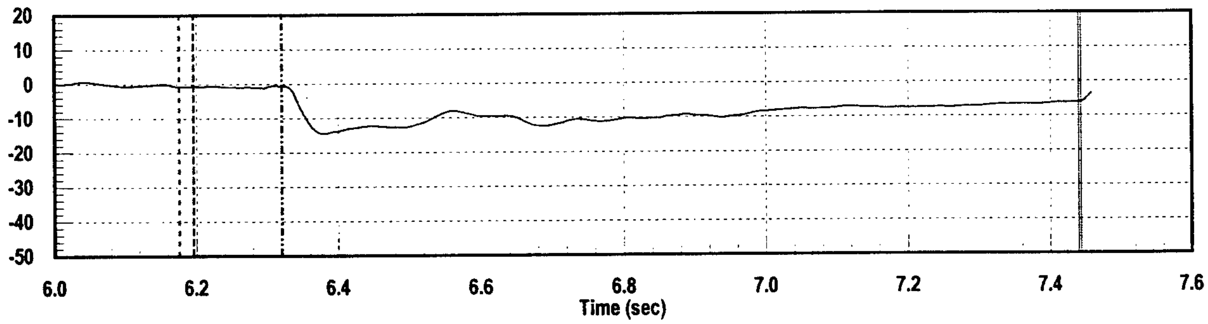


Seat Radical D



SL1050, 532 KEAS

Seat DRX D



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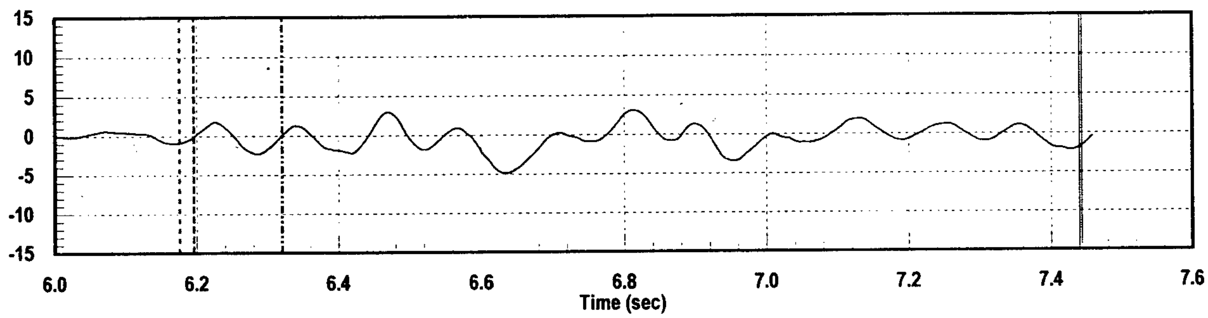
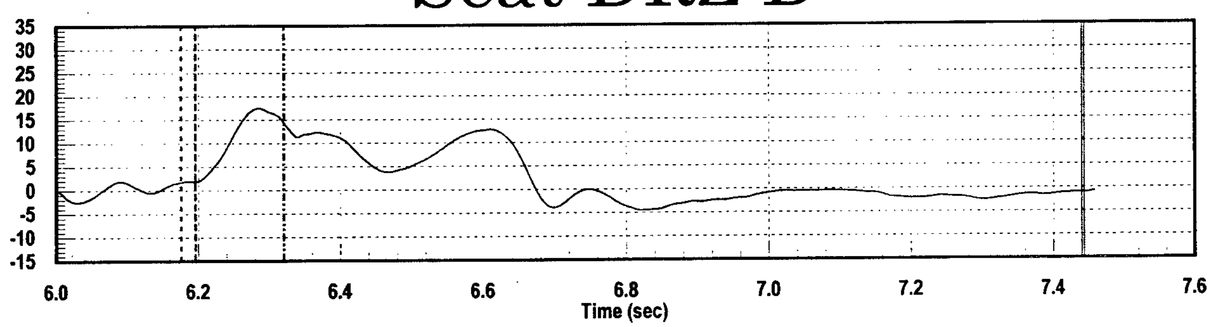
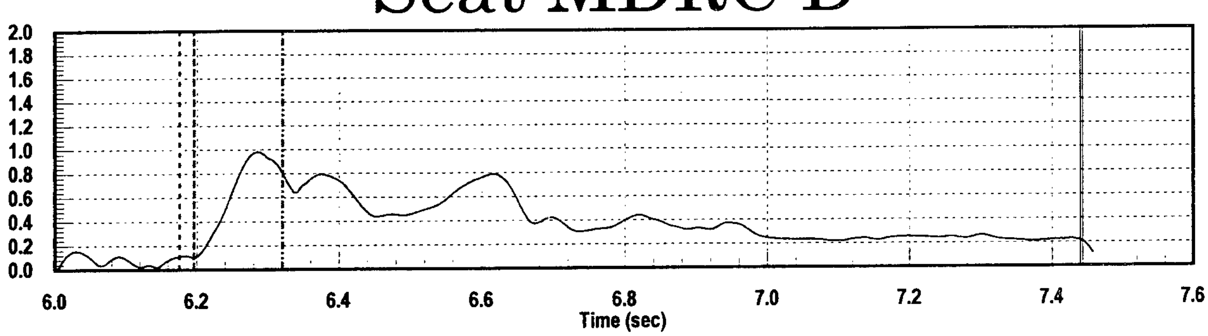


Seat DRZ D



Seat MDRC D



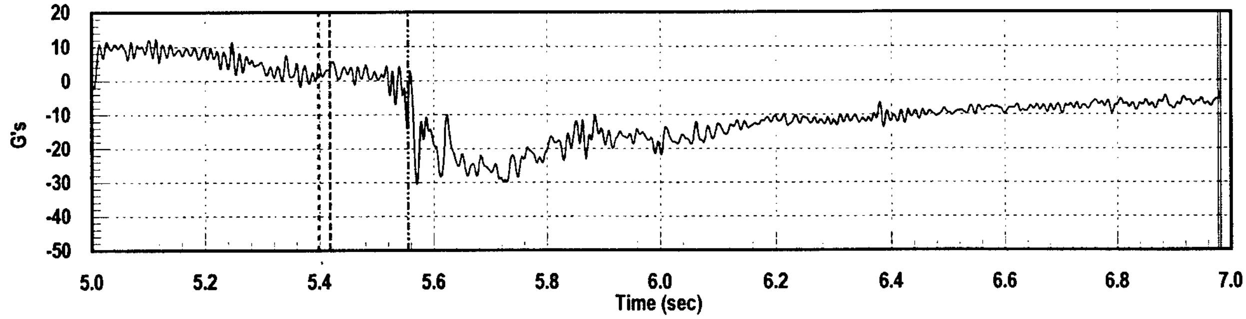
B-16

SL1295, 694 KEAS
Dynamic Response Analysis

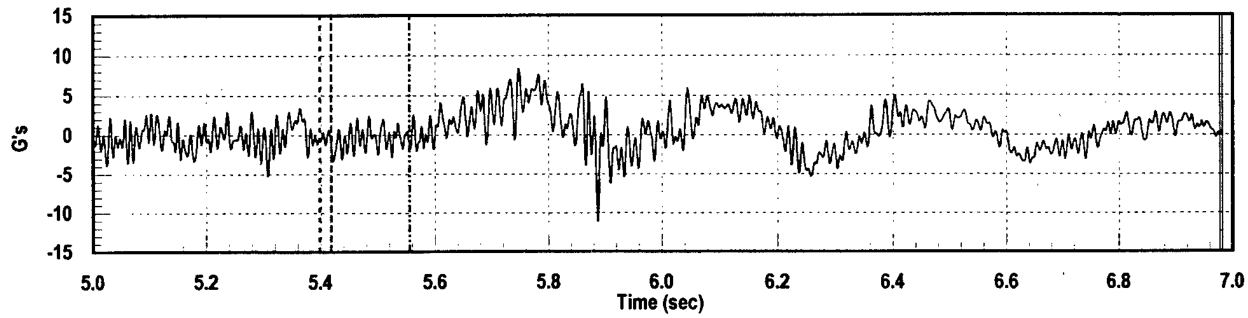
Seat Initiation	**Seat 1st Motion**	**Boom Firing**	**Seat Rail Sep.**	**Seat Man Sep.**

SL1295, 694 KEAS

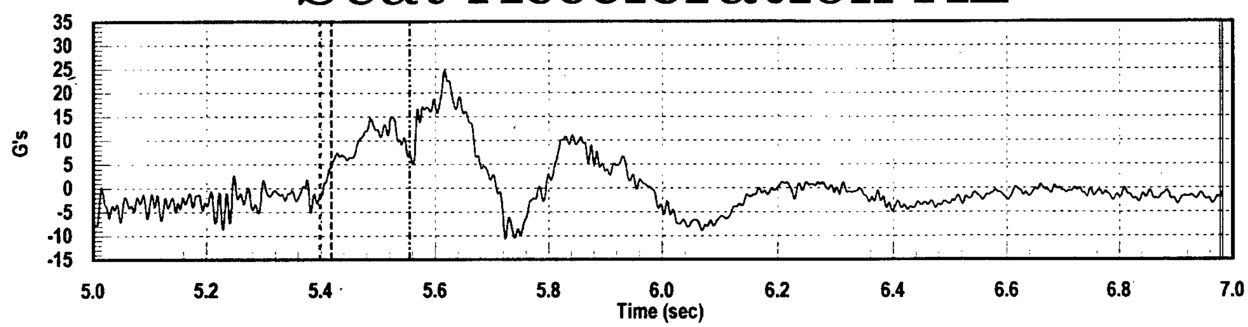
Seat Acceleration AX



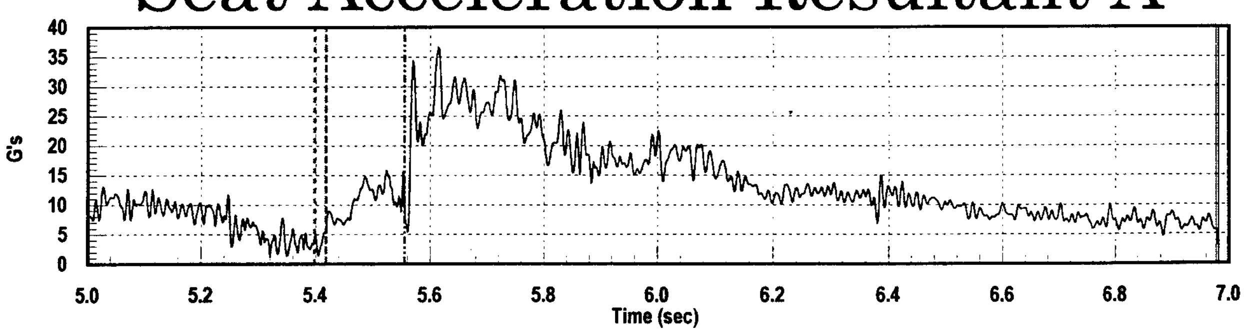
Seat Acceleration AY



Seat Acceleration AZ



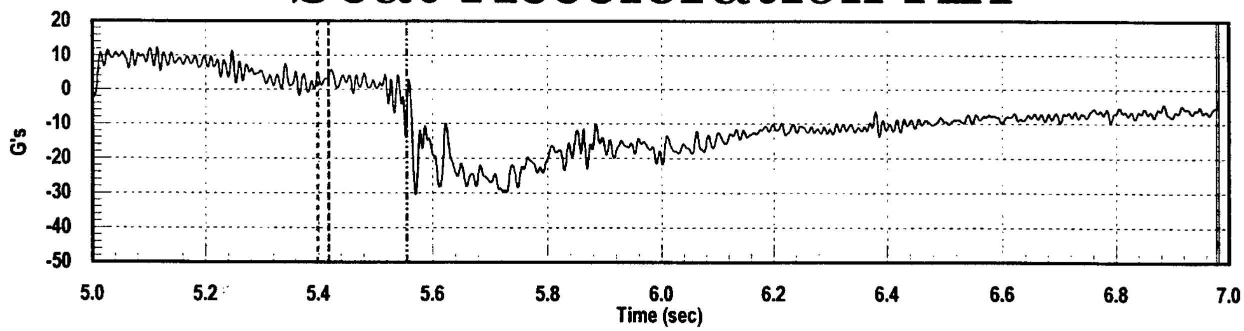
Seat Acceleration Resultant A



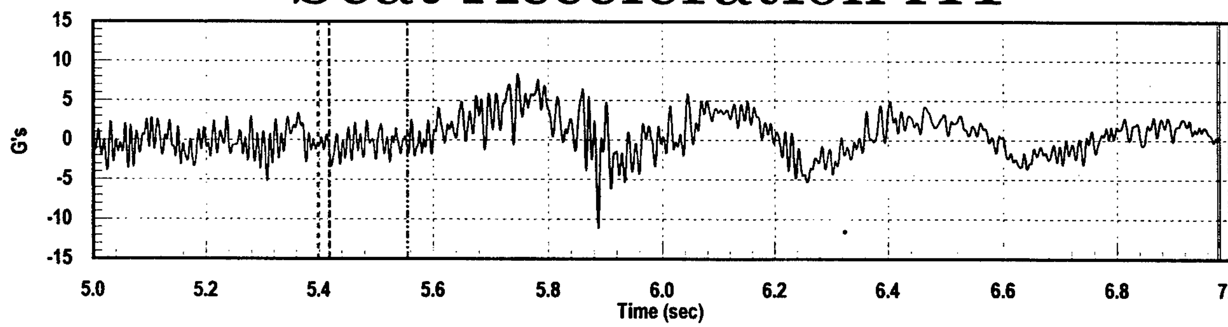
B-1

SL1295, 694 KEAS

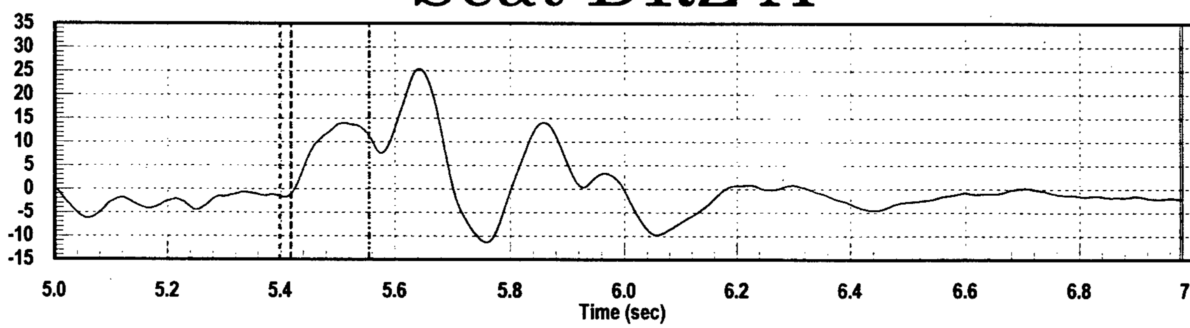
Seat Acceleration AX



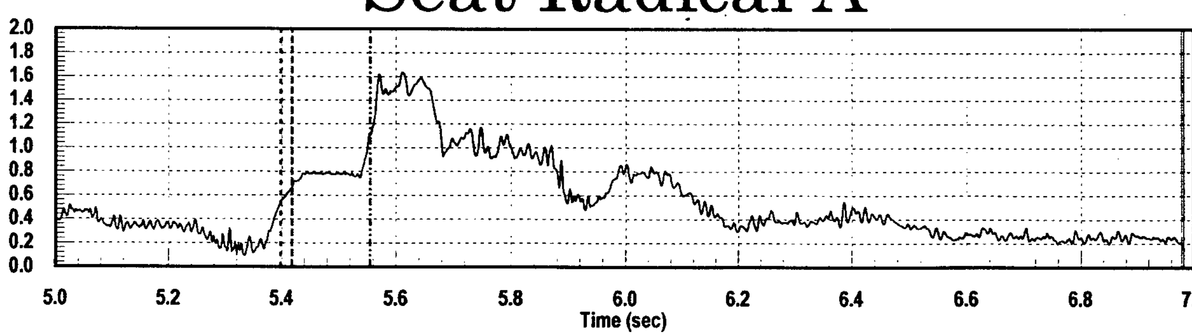
Seat Acceleration AY



Seat DRZ A



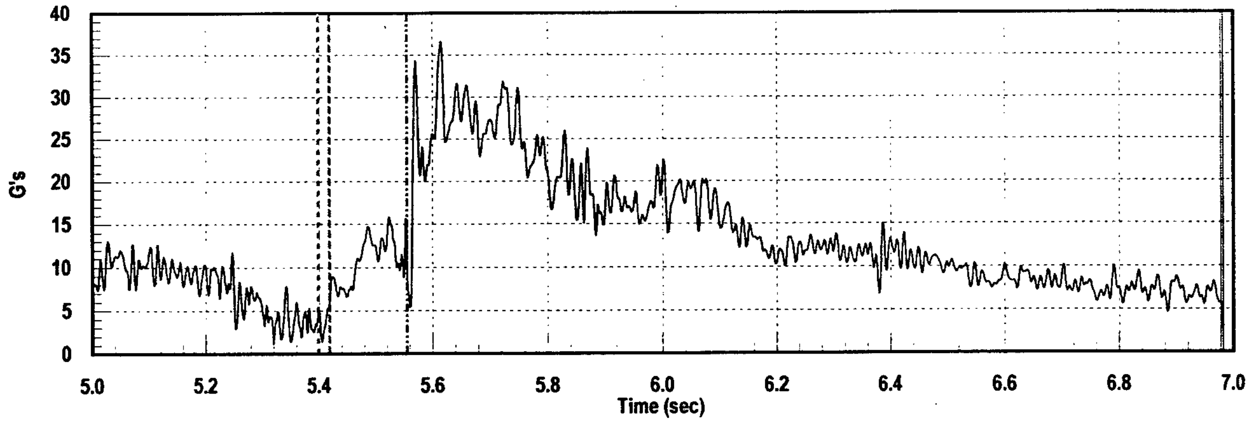
Seat Radical A



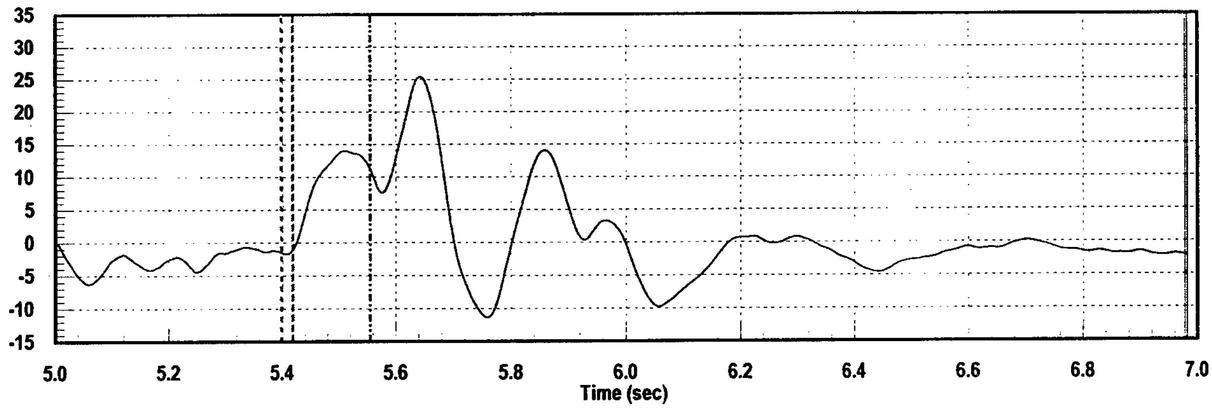
B-2

SL1295, 694 KEAS

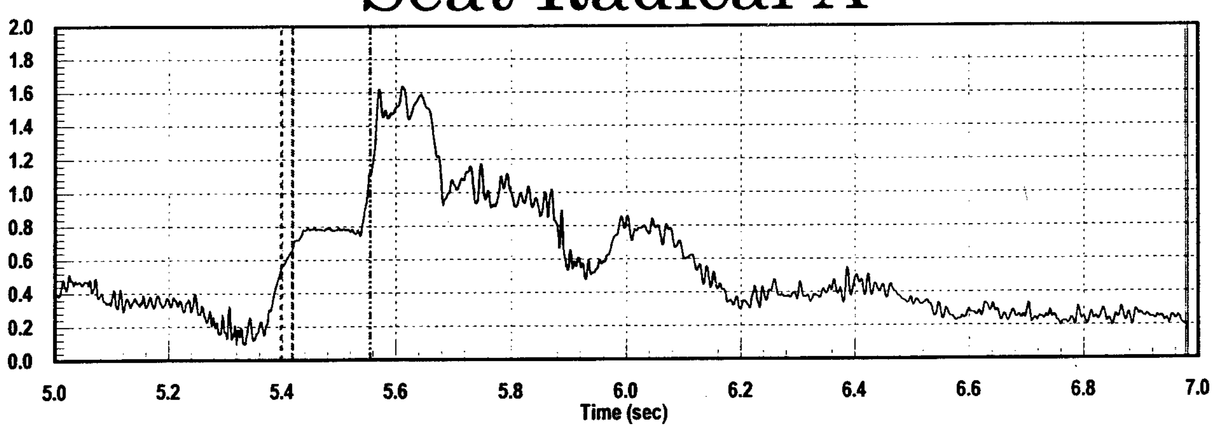
Seat Resultant A



Seat DRZ A



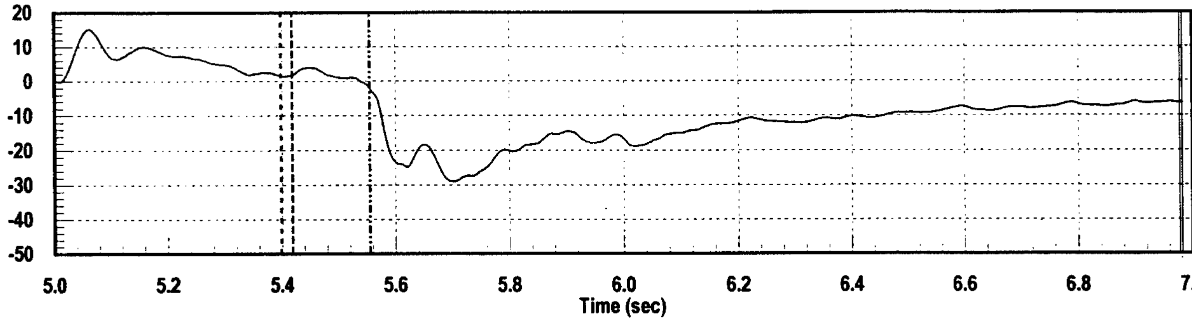
Seat Radical A



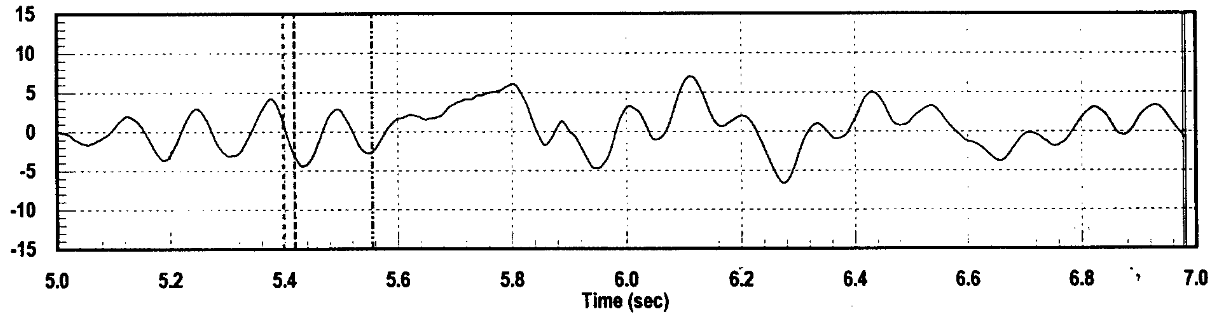
B-3

SL1295, 694 KEAS

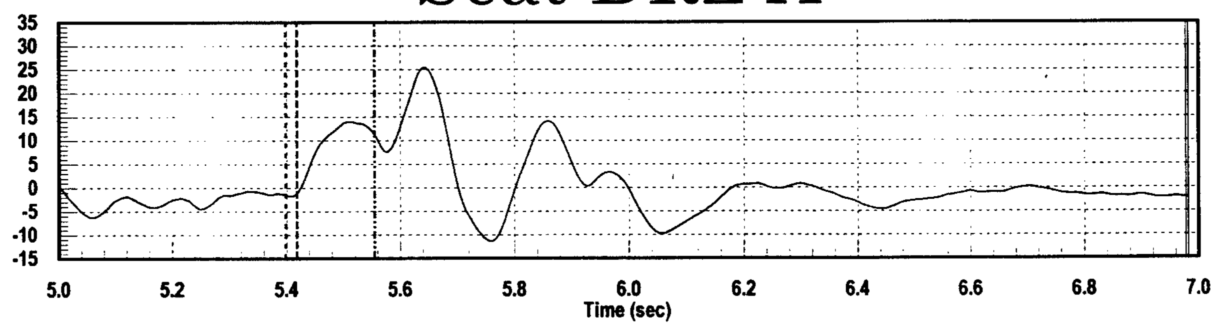
Seat DRX A



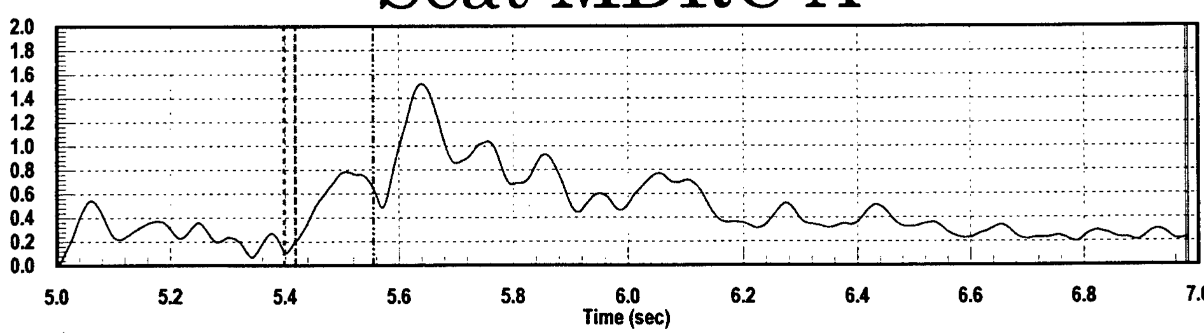
Seat DRY A



Seat DRZ A



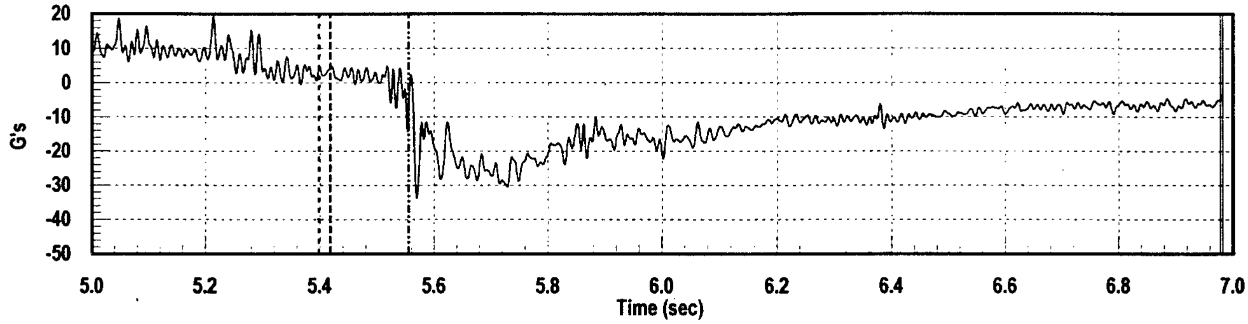
Seat MDRC A



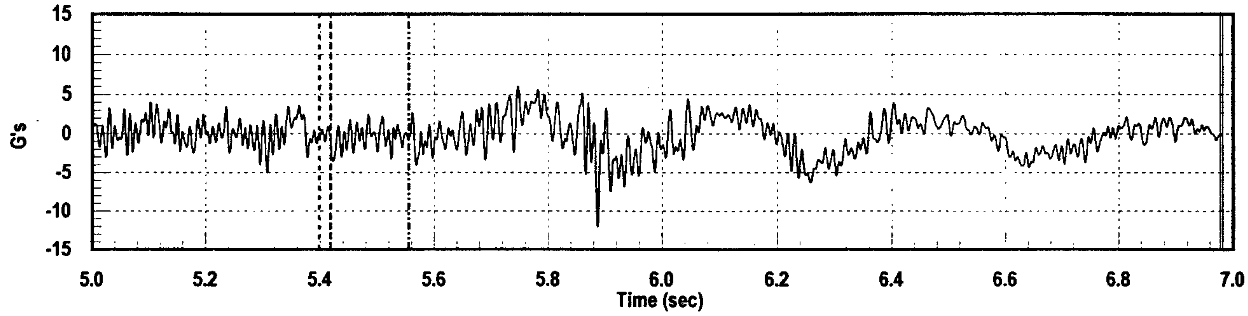
B-4

SL1295, 694 KEAS

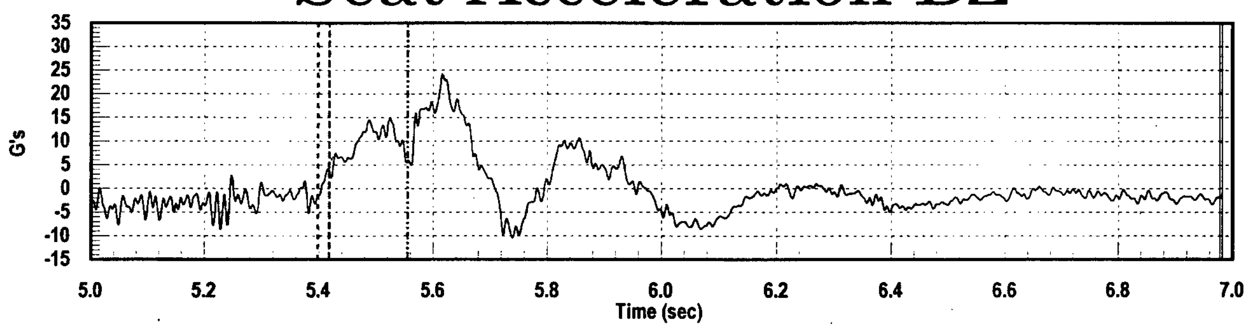
Seat Acceleration BX



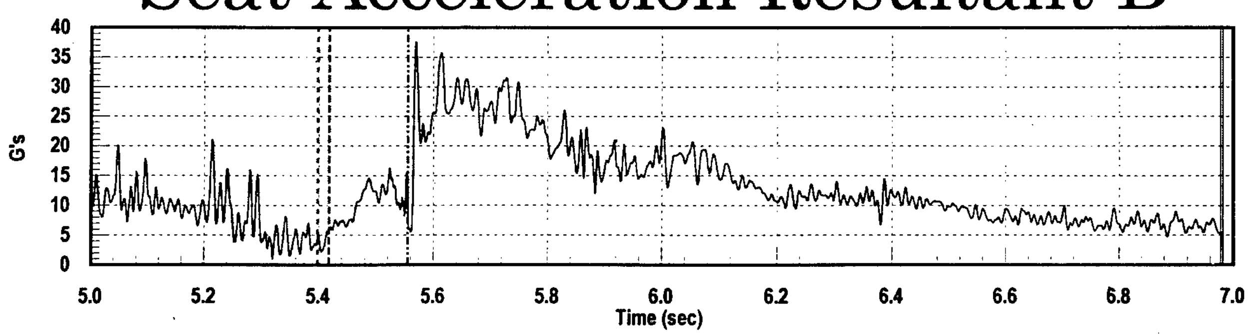
Seat Acceleration BY



Seat Acceleration BZ



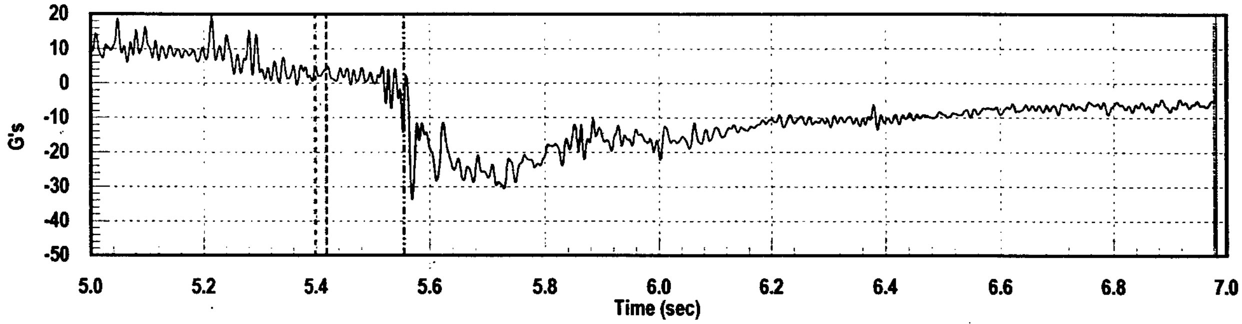
Seat Acceleration Resultant B



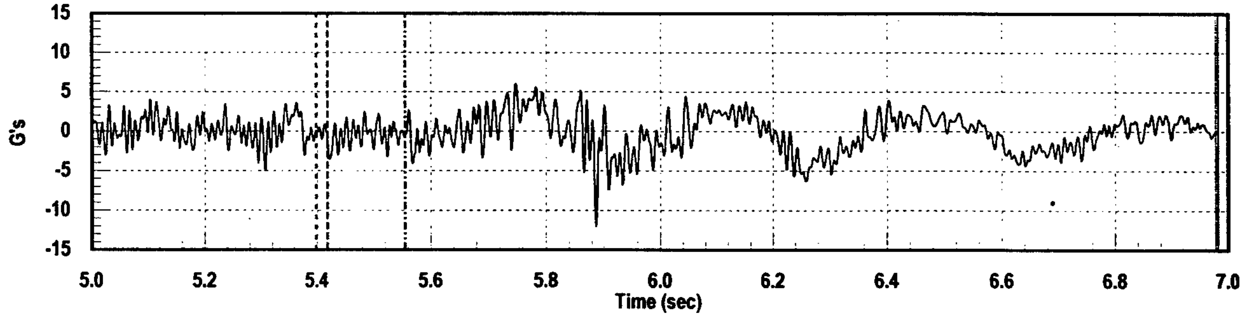
B-5

SL1295, 694 KEAS

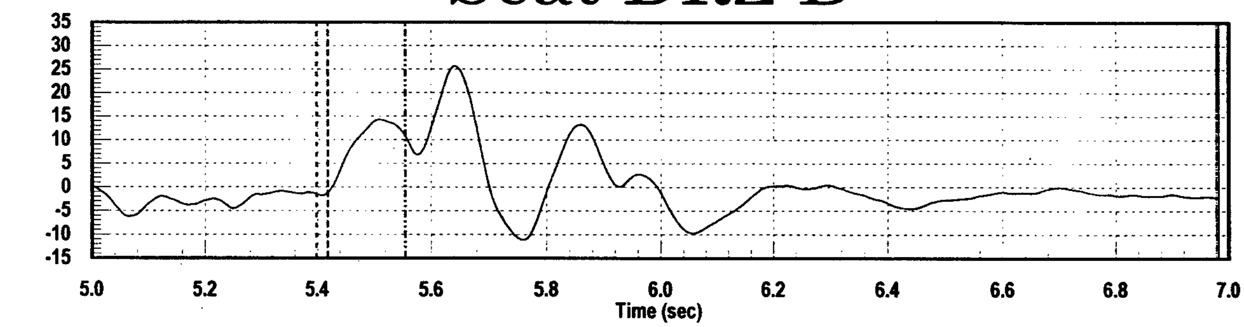
Seat Acceleration BX



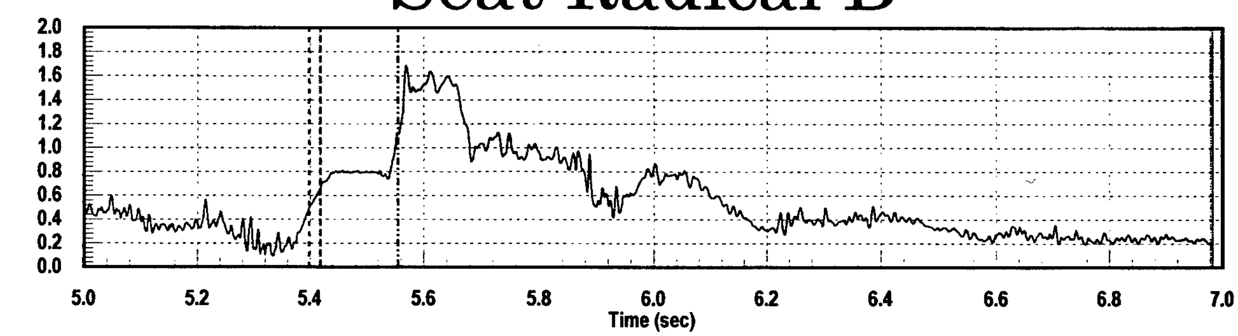
Seat Acceleration BY



Seat DRZ B



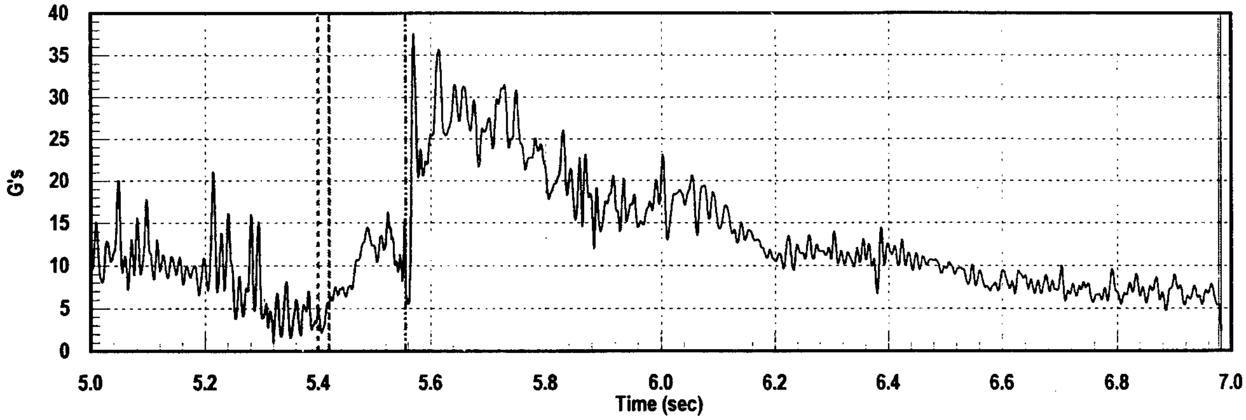
Seat Radical B



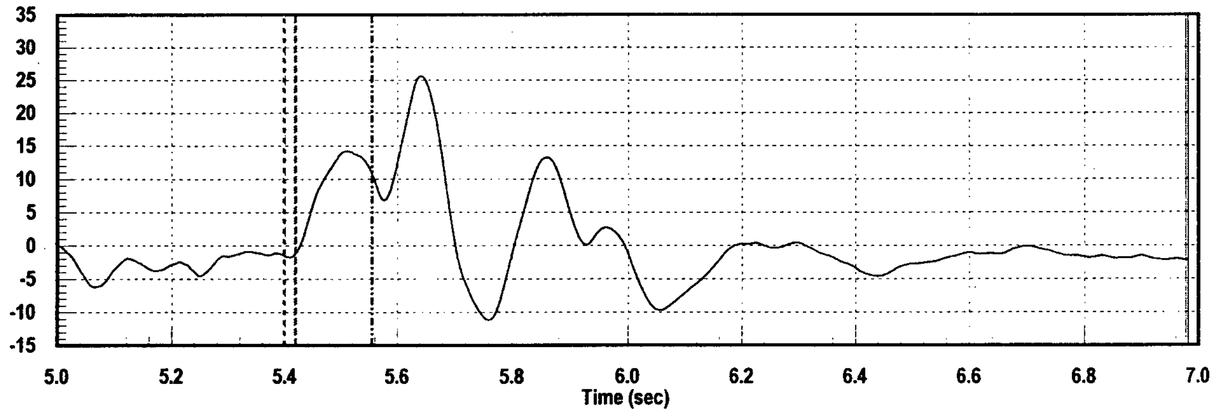
B-6

SL1295, 694 KEAS

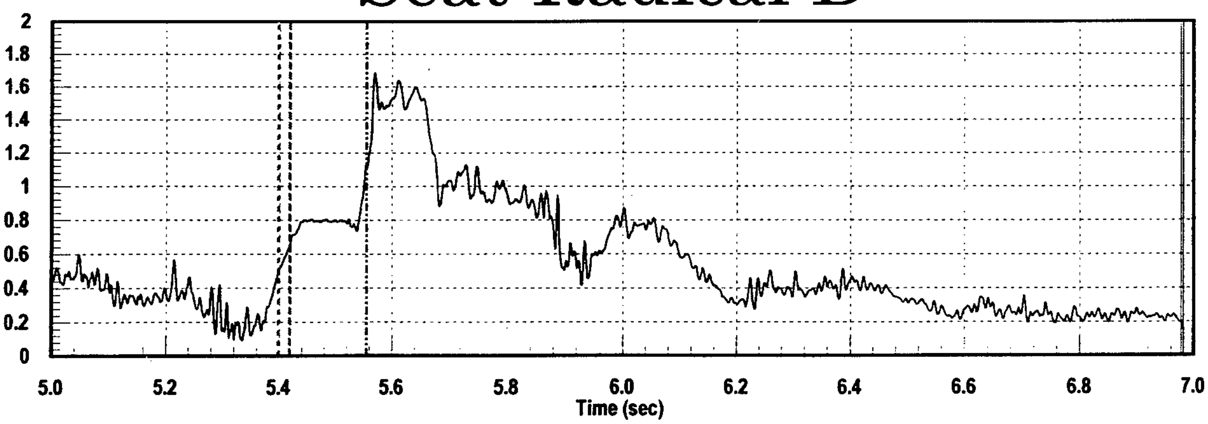
Seat Resultant B



Seat DRZ B



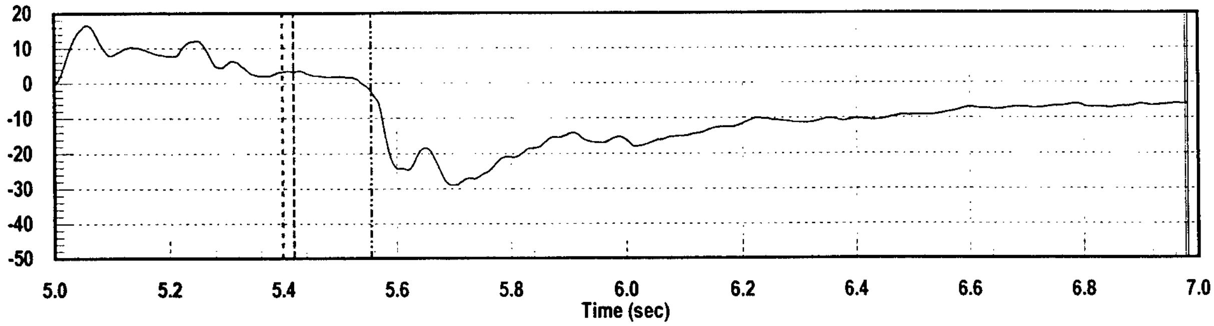
Seat Radical B



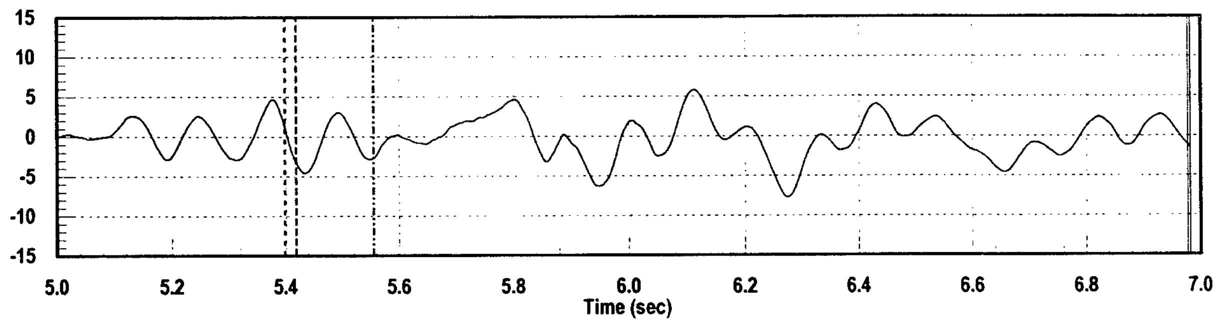
B-7

SL1295, 694 KEAS

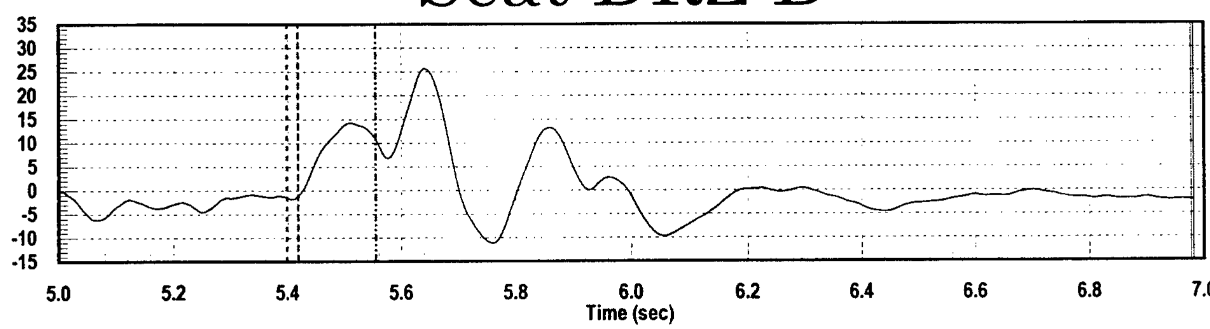
Seat DRX B



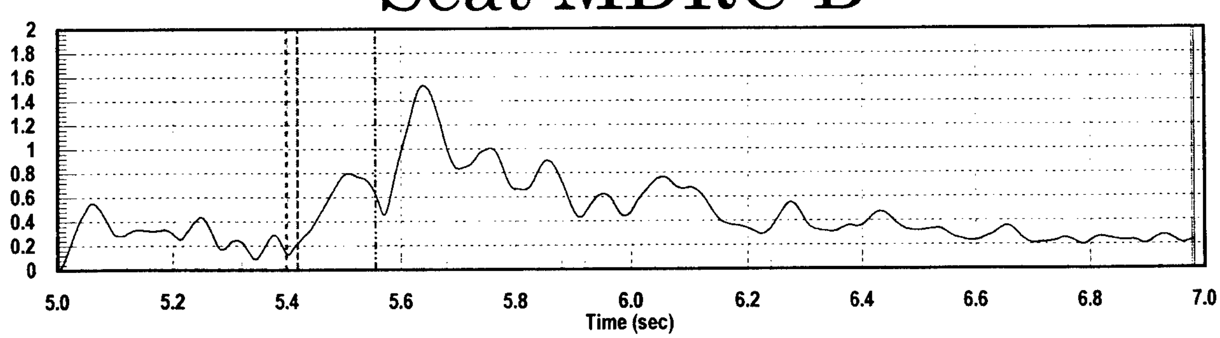
Seat DRY B



Seat DRZ B



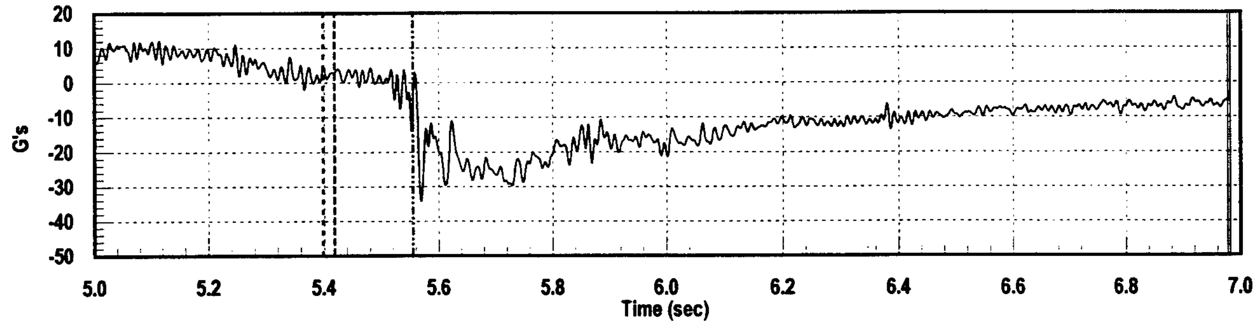
Seat MDRC B



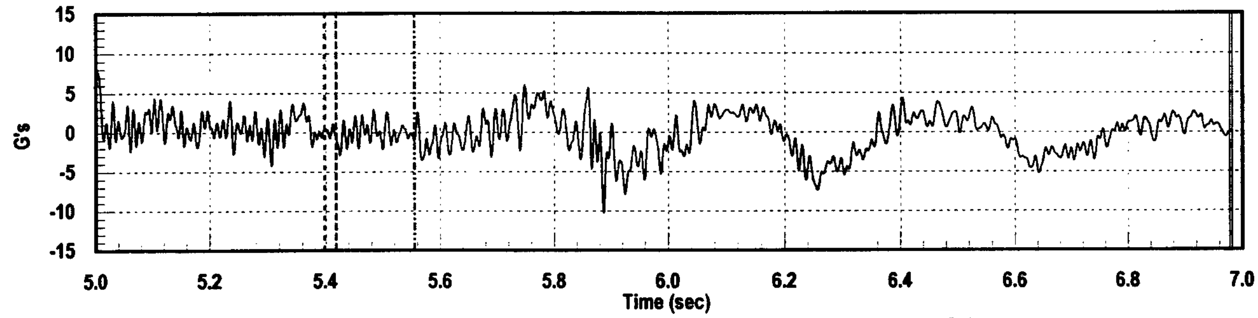
B-8

SL1295, 694 KEAS

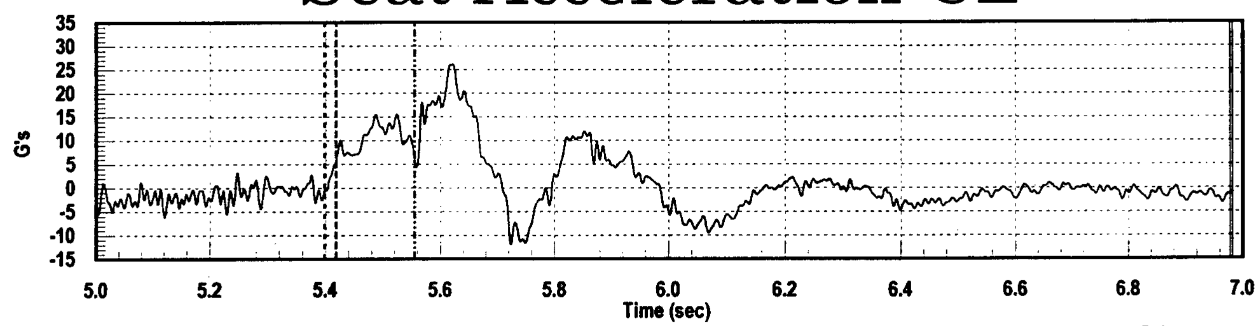
Seat Acceleration CX



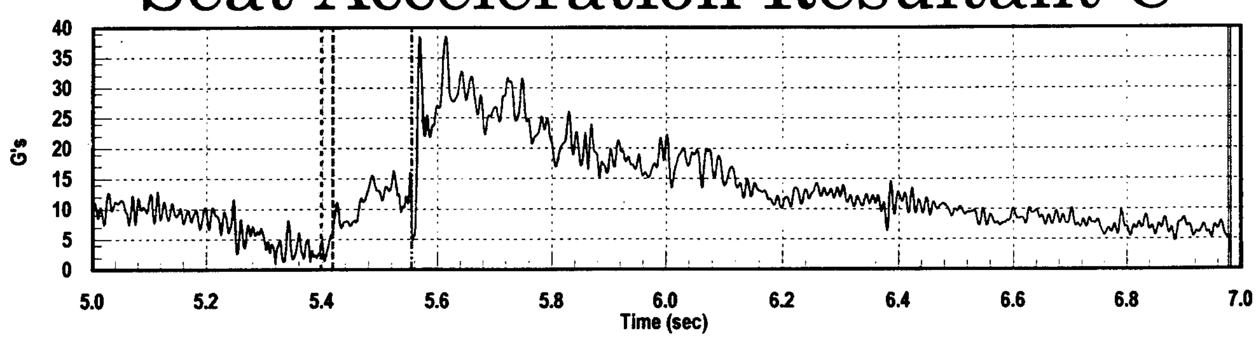
Seat Acceleration CY



Seat Acceleration CZ



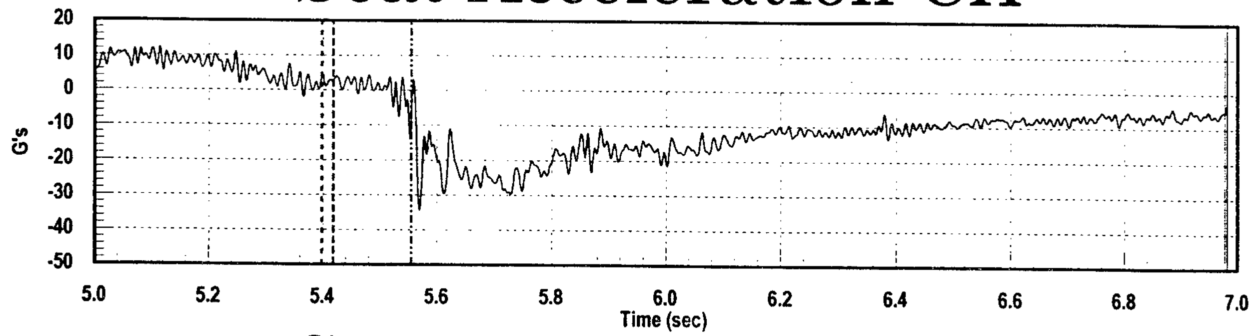
Seat Acceleration Resultant C



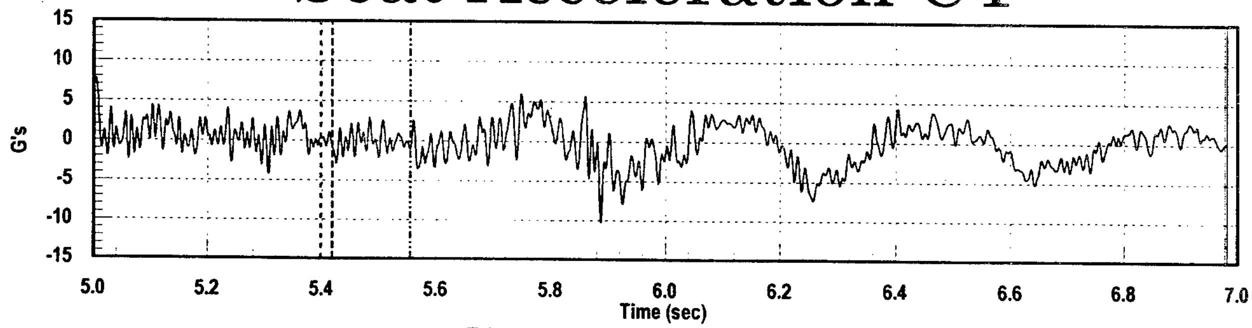
B-9

SL1295, 694 KEAS

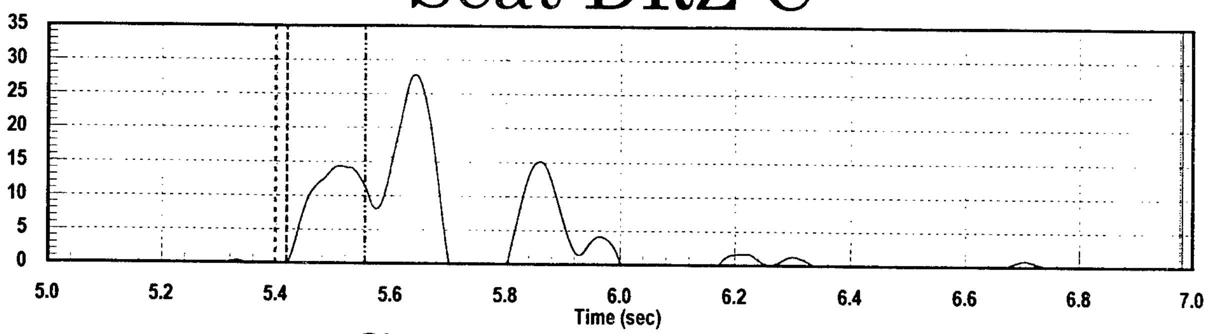
Seat Acceleration CX



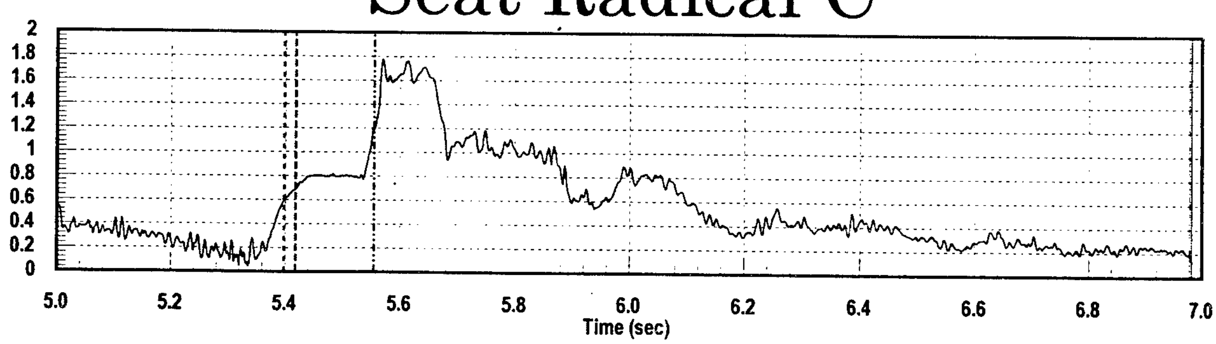
Seat Acceleration CY



Seat DRZ C

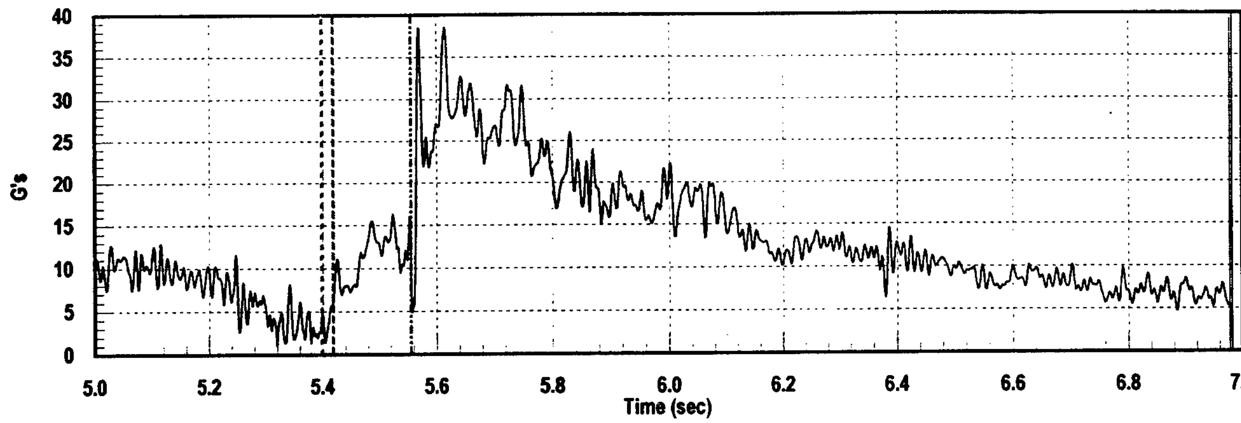


Seat Radical C

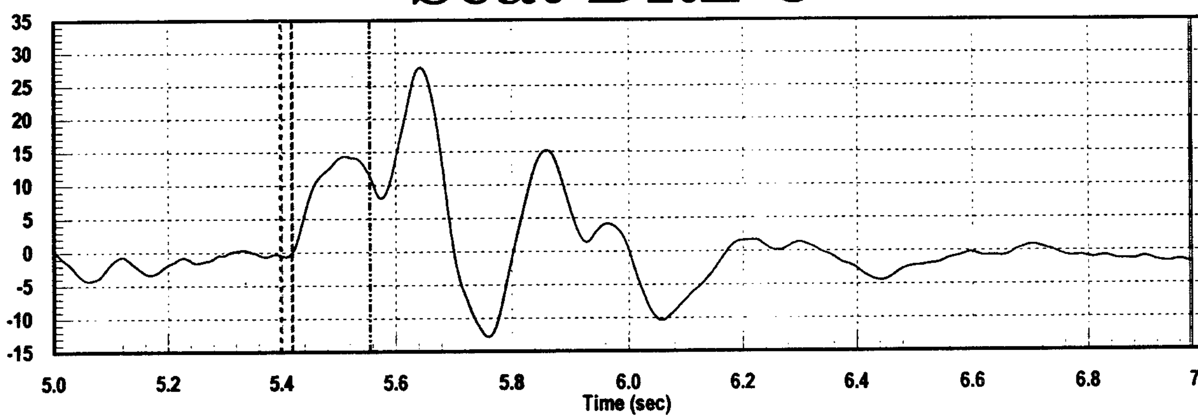


SL1295, 694 KEAS

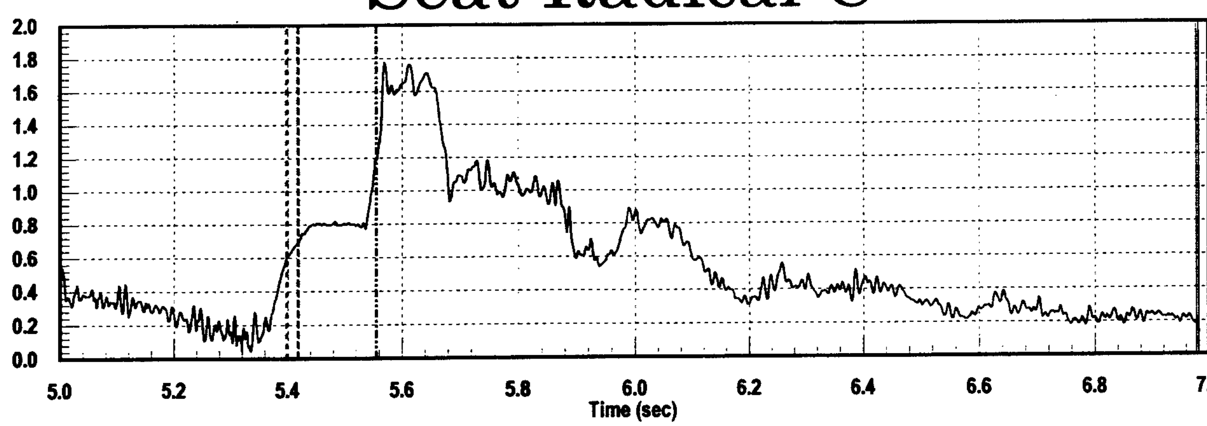
Seat Resultant C



Seat DRZ C



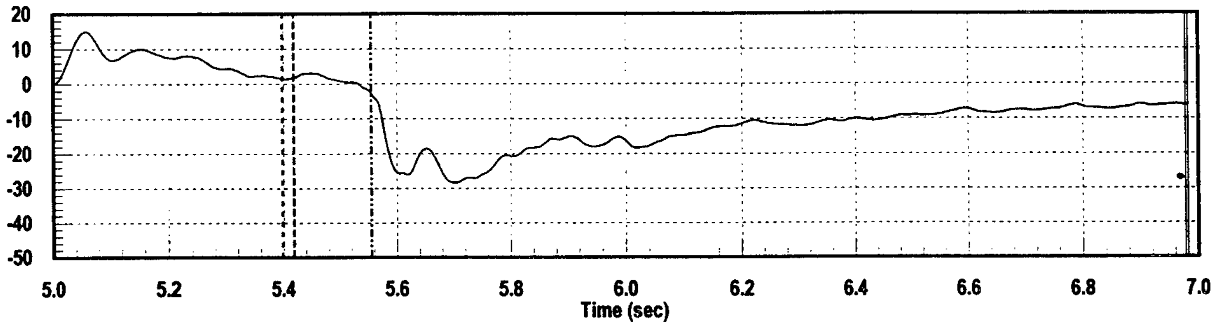
Seat Radical C



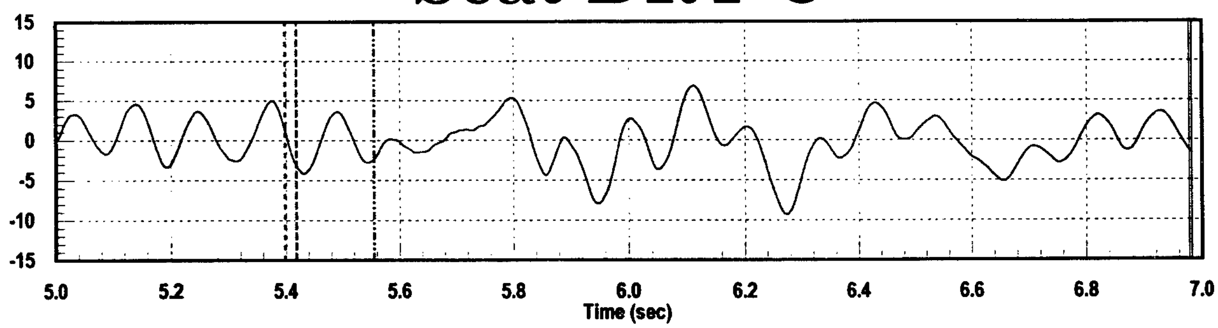
B-11

SL1295, 694 KEAS

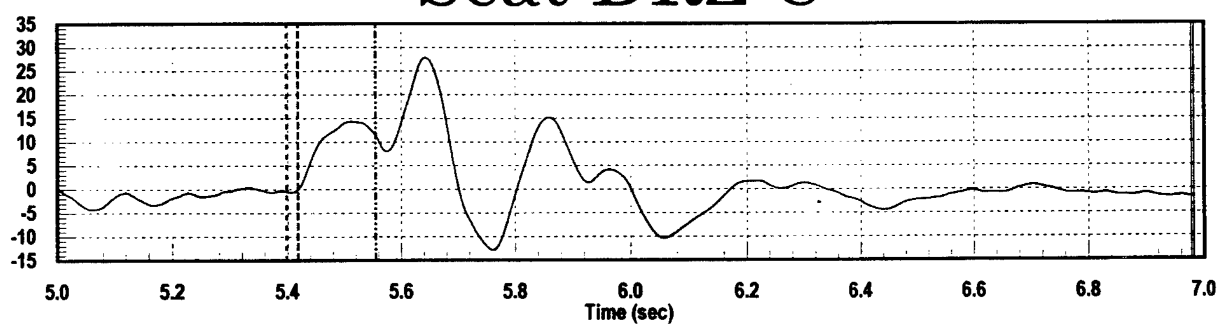
Seat DRX C



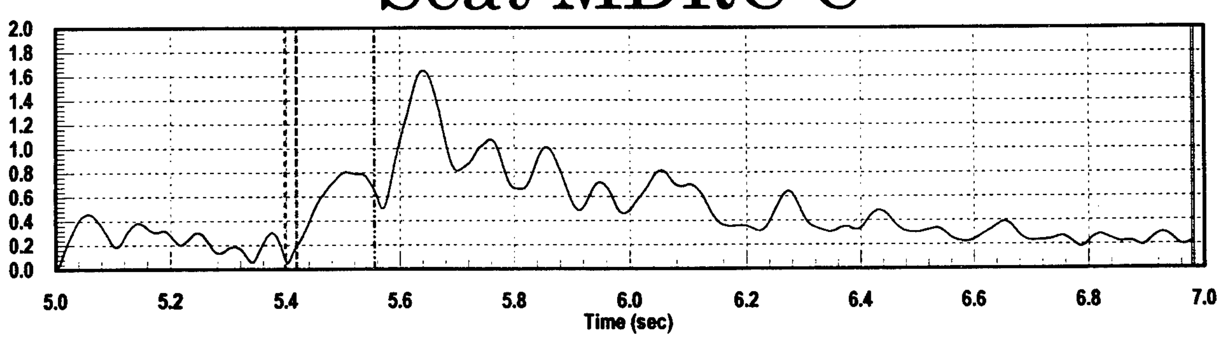
Seat DRY C



Seat DRZ C



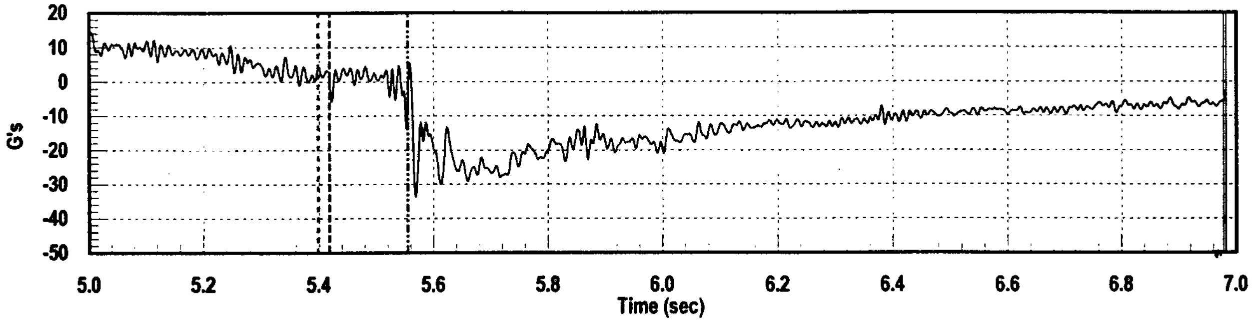
Seat MDRC C



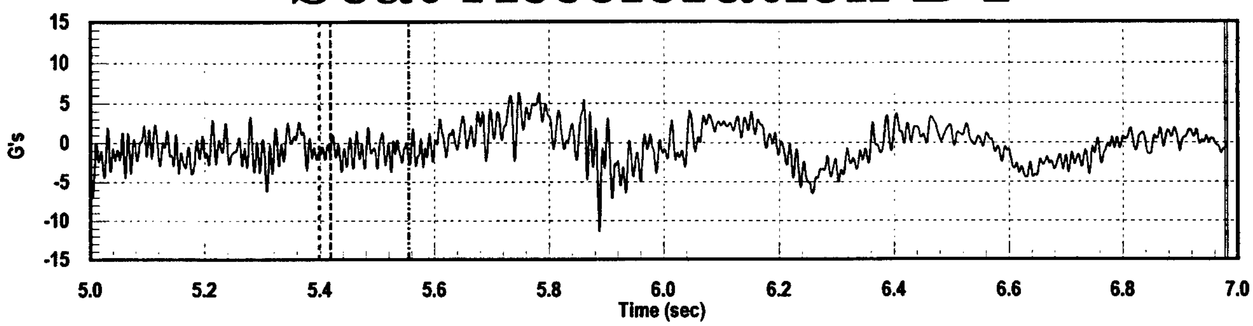
B-12

SL1295, 694 KEAS

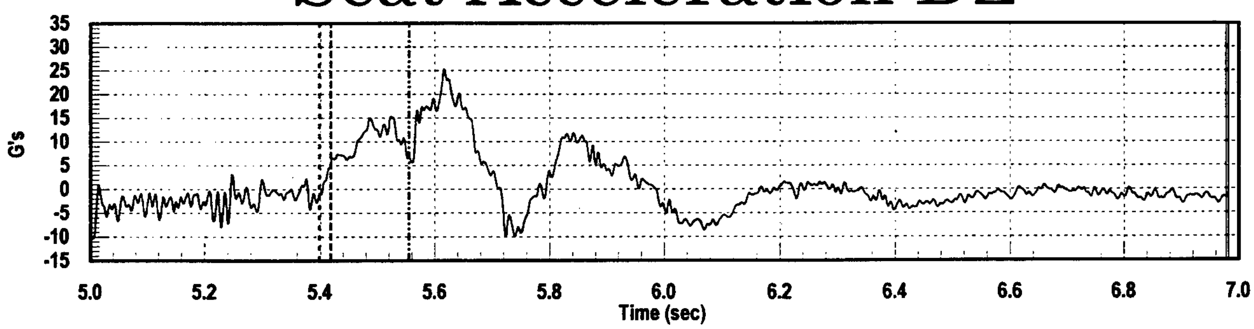
Seat Acceleration DX



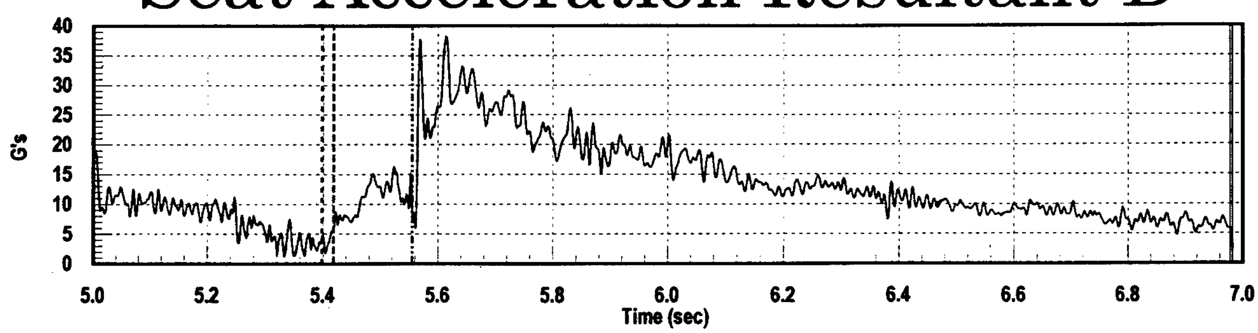
Seat Acceleration DY



Seat Acceleration DZ

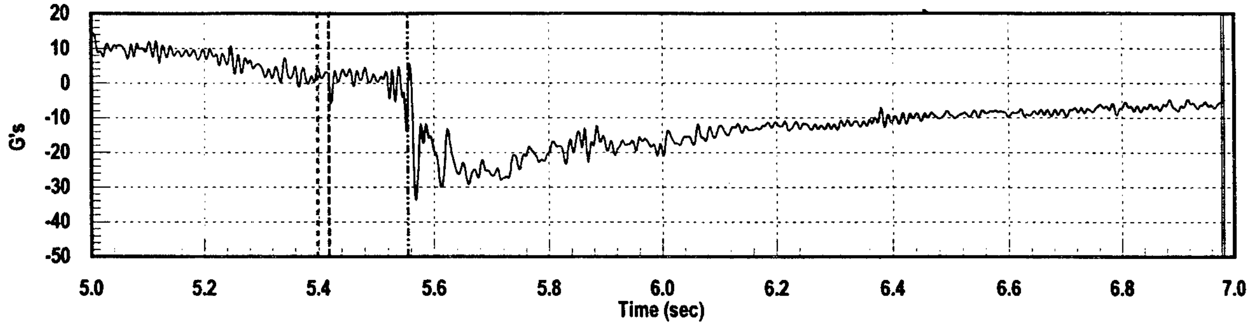


Seat Acceleration Resultant D

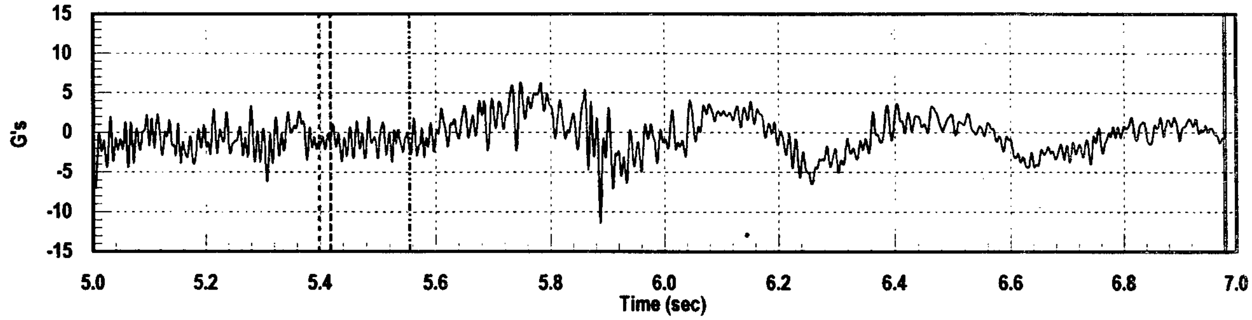


SL1295, 694 KEAS

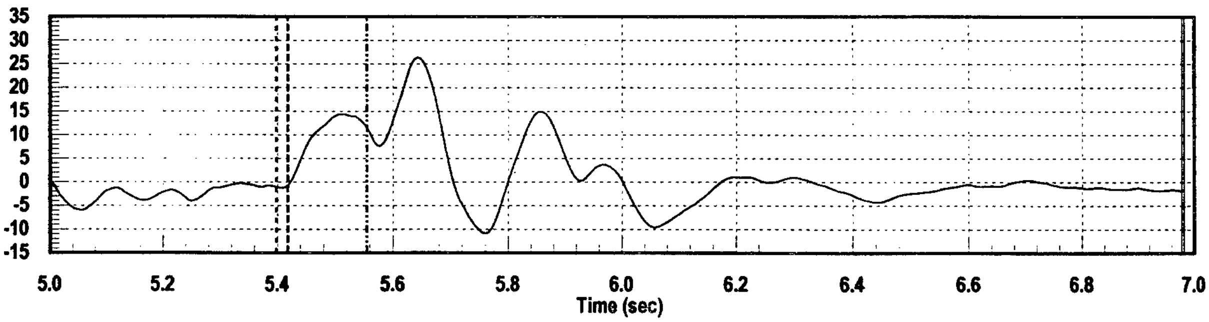
Seat Acceleration DX



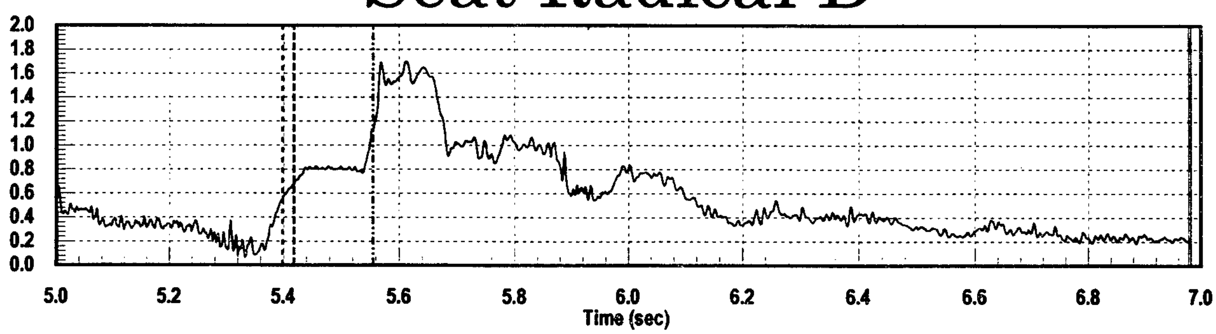
Seat Acceleration DY



Seat DRZ D



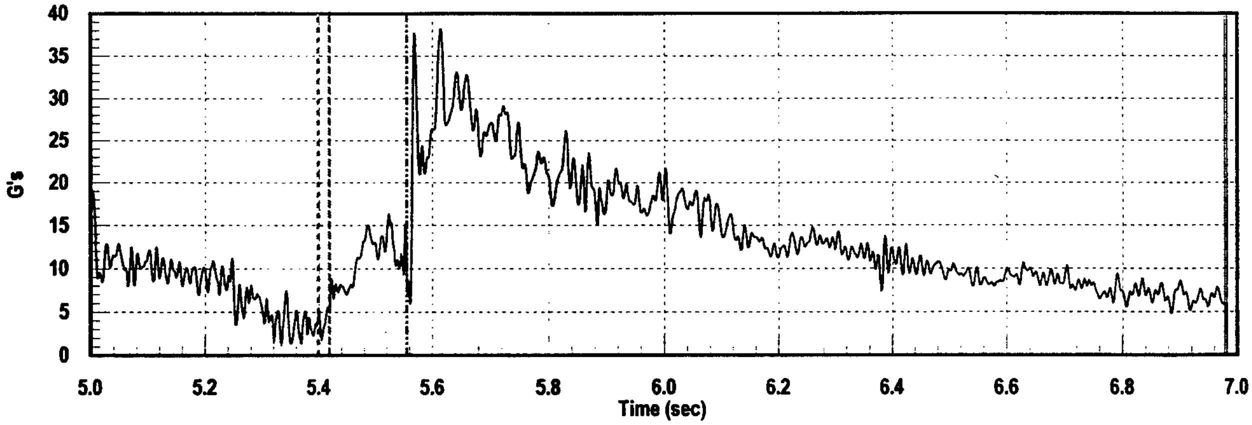
Seat Radical D



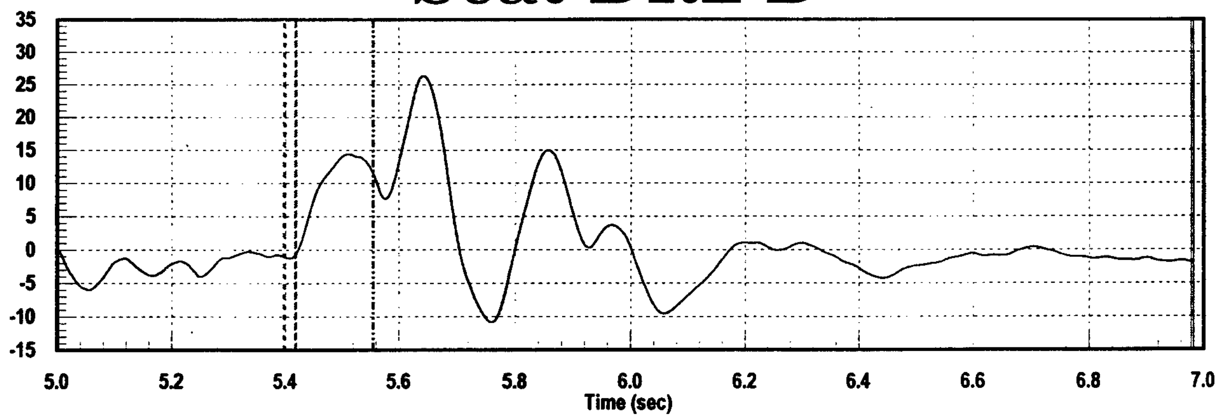
B-14

SL1295, 694 KEAS

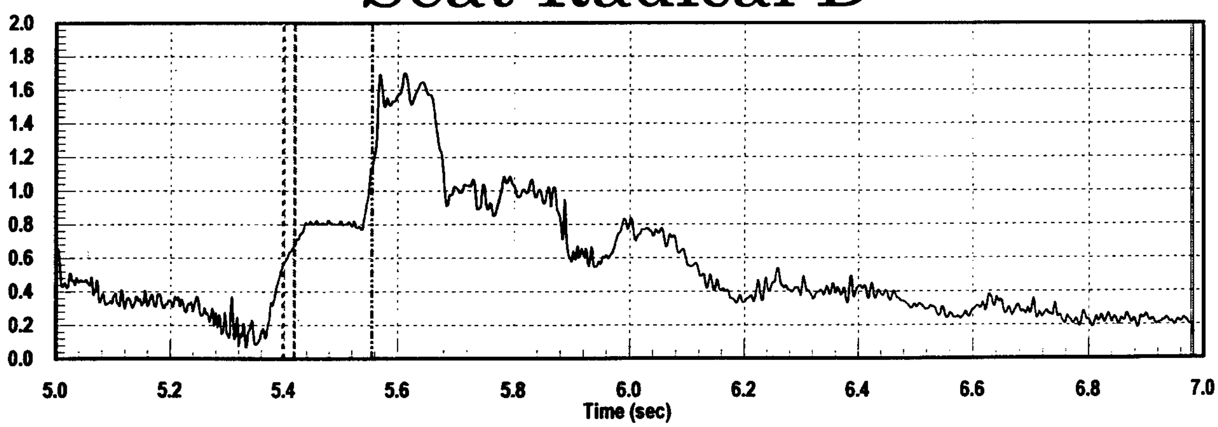
Seat Resultant D



Seat DRZ D



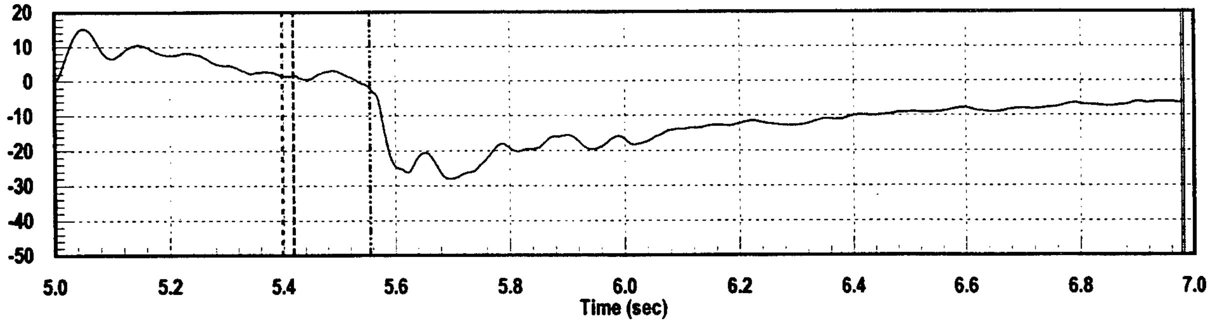
Seat Radical D



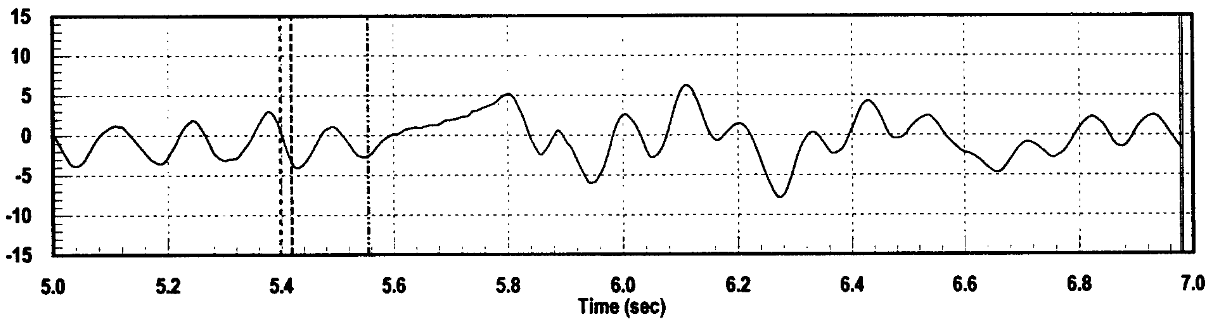
B-15

SL1295, 694 KEAS

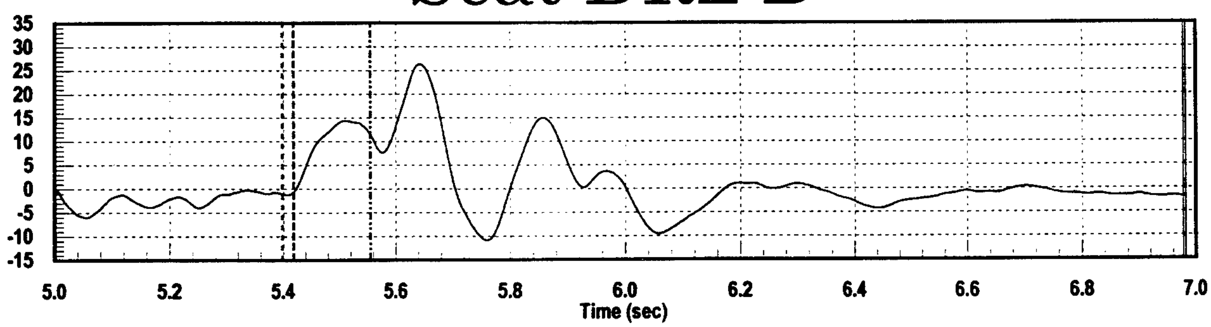
Seat DRX D



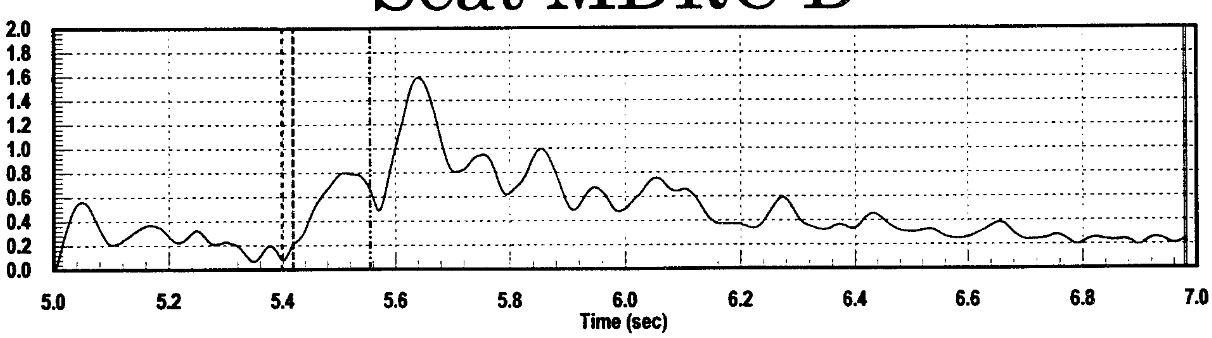
Seat DRY D



Seat DRZ D



Seat MDRC D



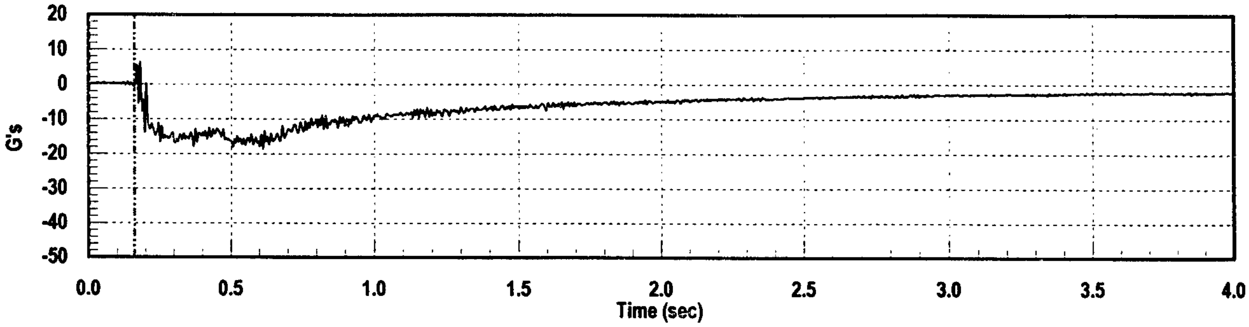
B-16

FL110005SL, 550 KEAS, 17,000 Ft
Dynamic Response Analysis

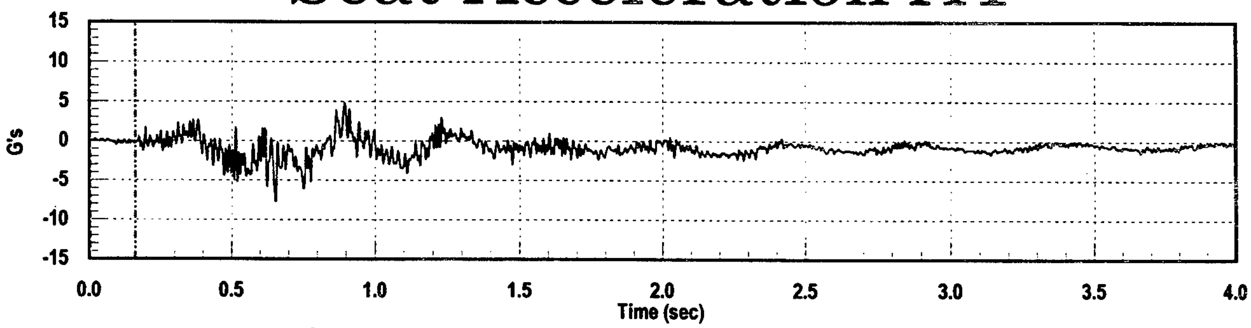
Seat Initiation	**Seat 1st Motion**	**Boom Firing**	**Seat Rail Sep.**	**Seat Man Sep.**

FL110005SL, 550 KEAS, 17,000 Ft

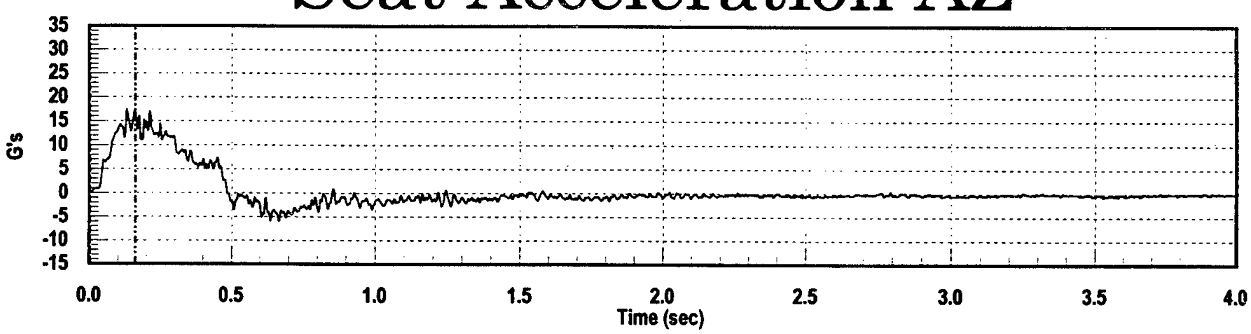
Seat Acceleration AX



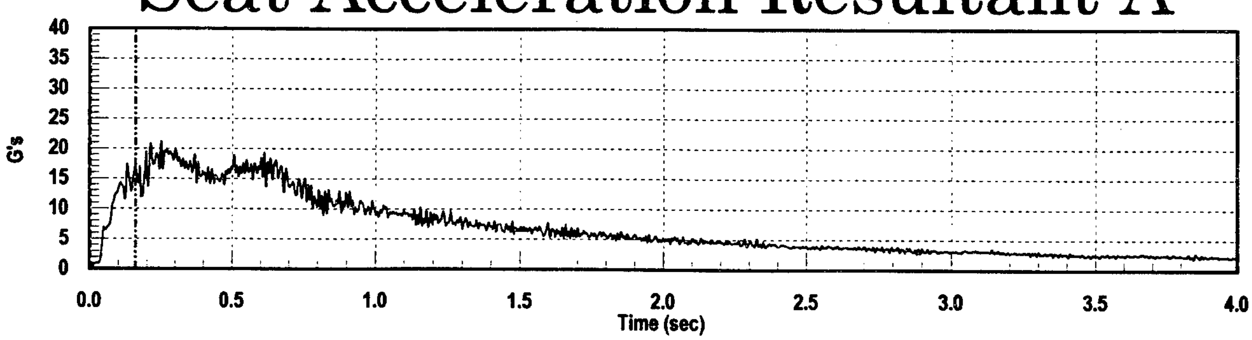
Seat Acceleration AY



Seat Acceleration AZ



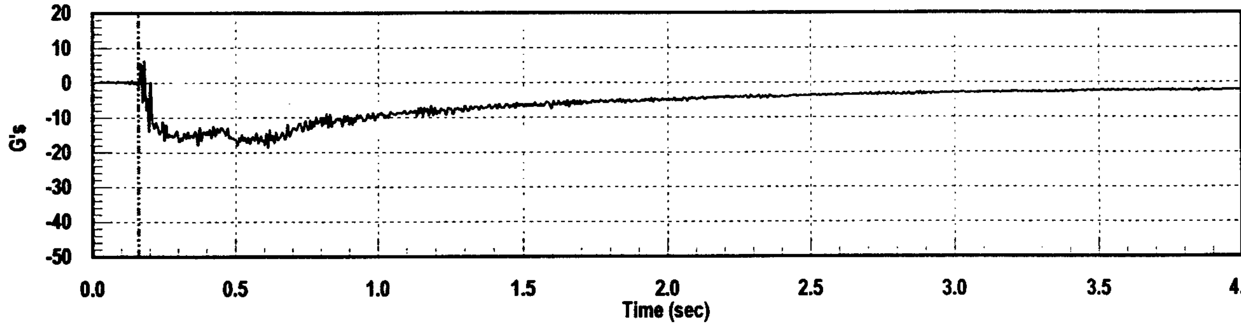
Seat Acceleration Resultant A



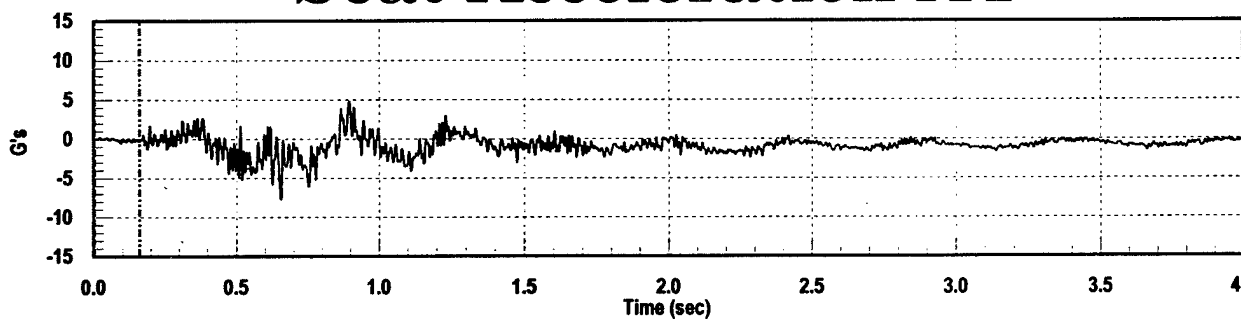
B-1

FL110005SL, 550 KEAS, 17,000 Ft

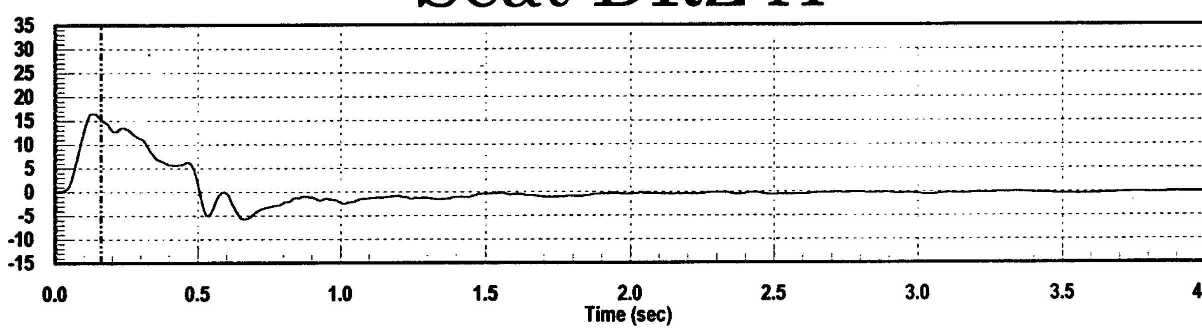
Seat Acceleration AX



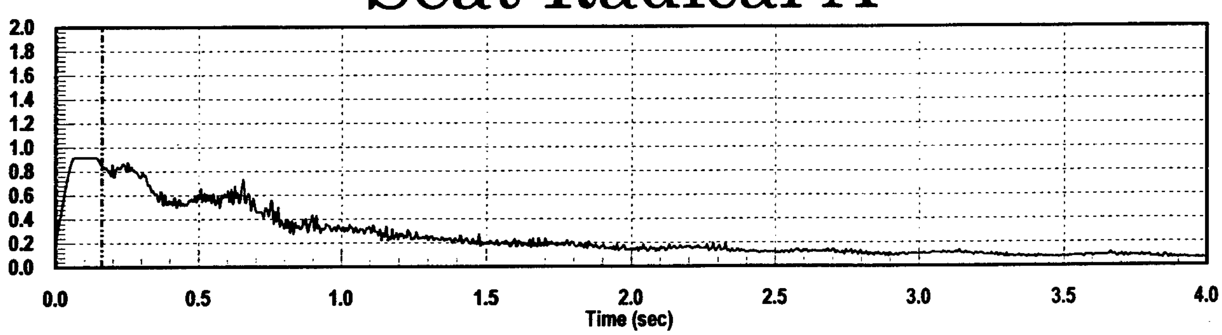
Seat Acceleration AY



Seat DRZ A



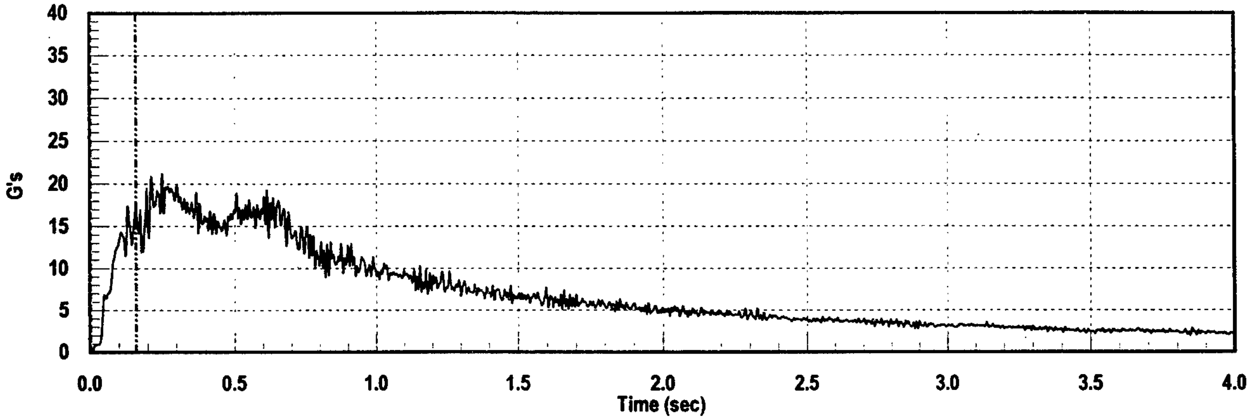
Seat Radical A



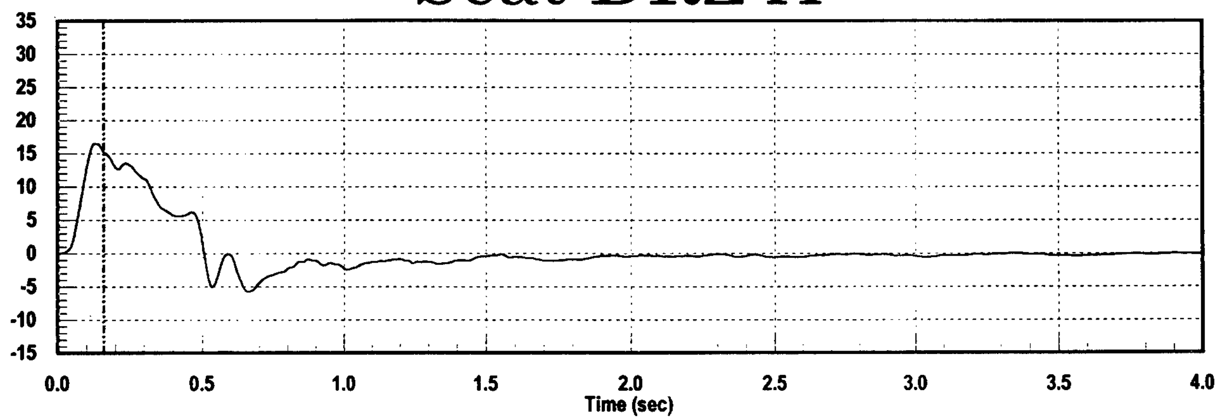
B-2

FL110005SL, 550 KEAS, 17,000 Ft

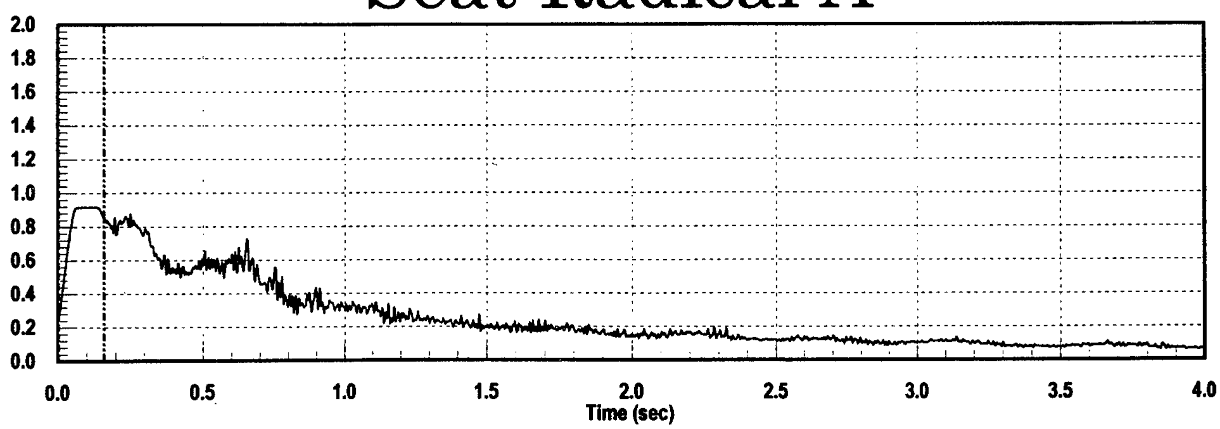
Seat Resultant A



Seat DRZ A



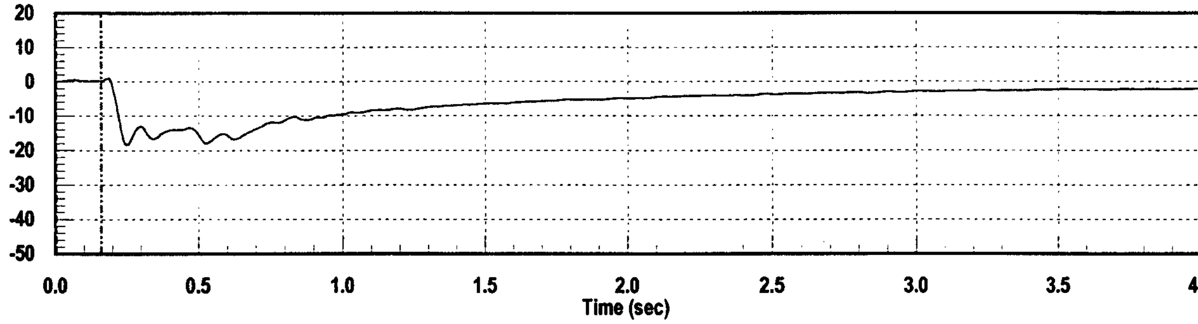
Seat Radical A



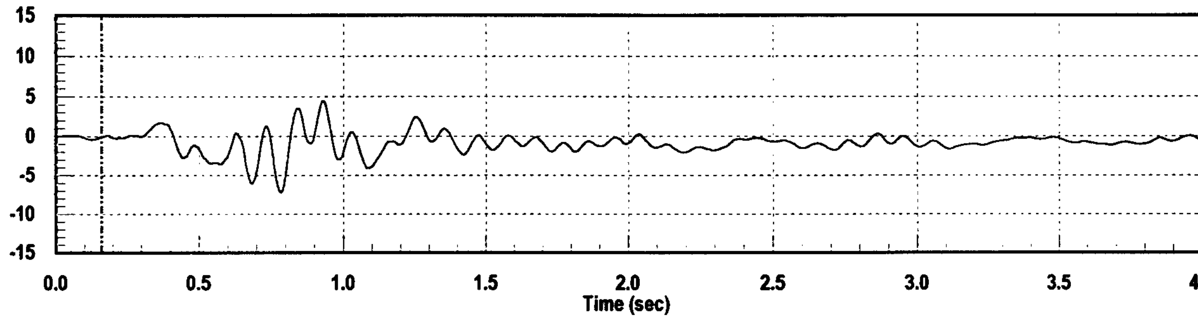
B-3

FL110005SL, 550 KEAS, 17,000 Ft

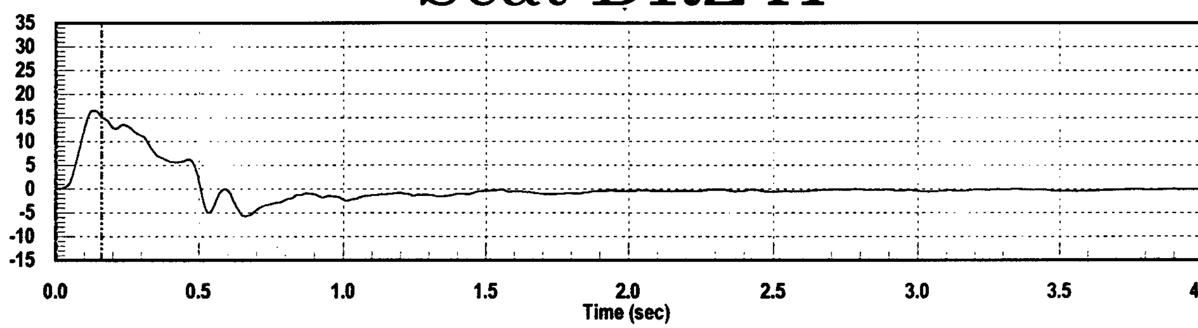
Seat DRX A



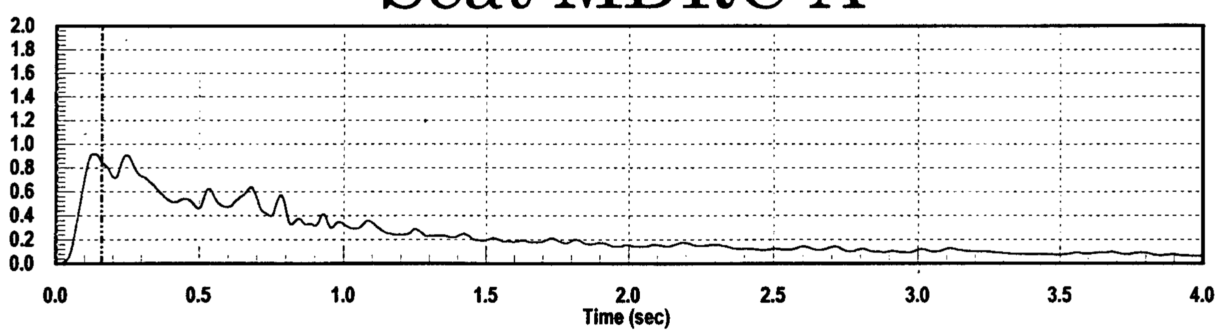
Seat DRY A



Seat DRZ A



Seat MDRC A



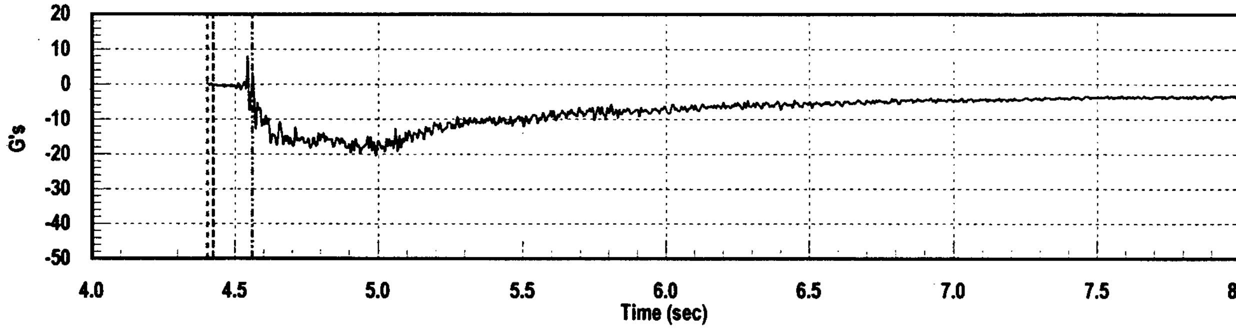
B-4

FL110005, 545 KEAS, 19,000 Ft
Dynamic Response Analysis

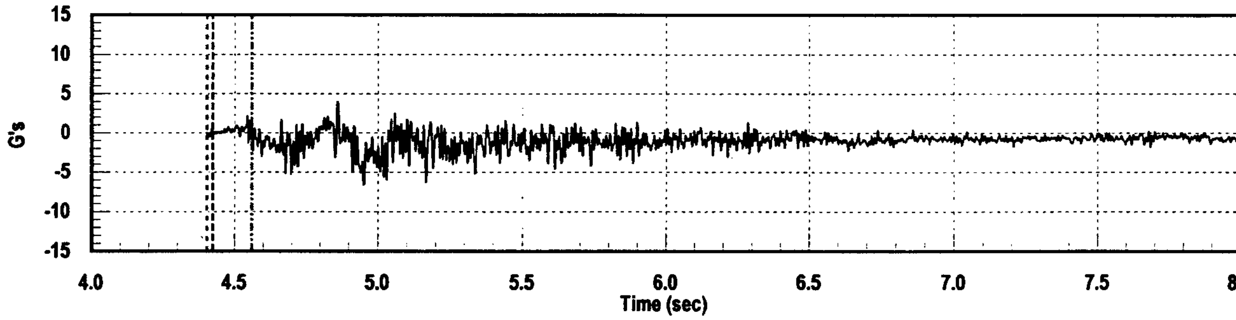
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL110005, 545 KEAS, 19,000 Ft

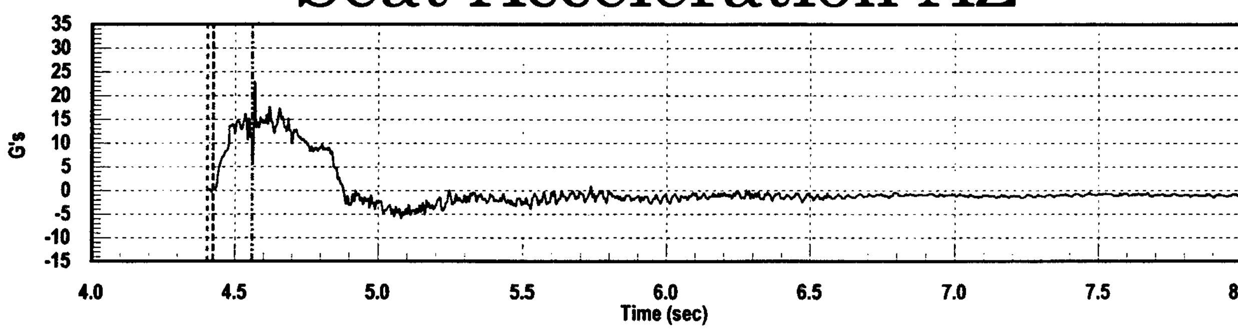
Seat Acceleration AX



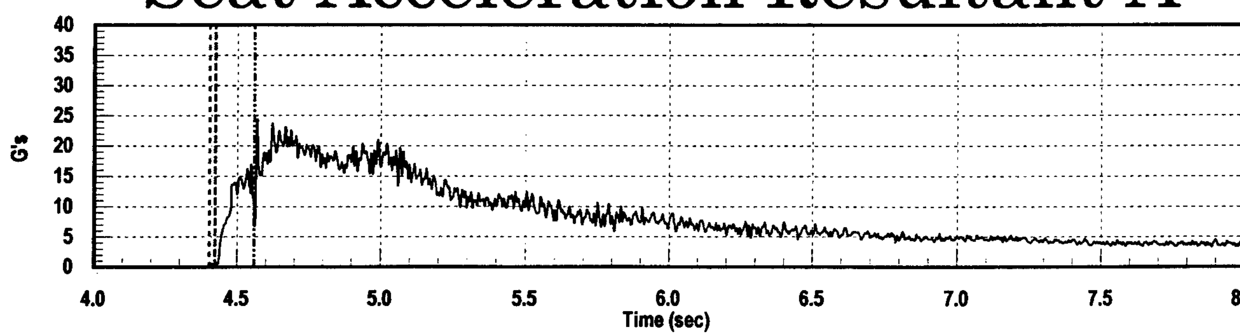
Seat Acceleration AY



Seat Acceleration AZ



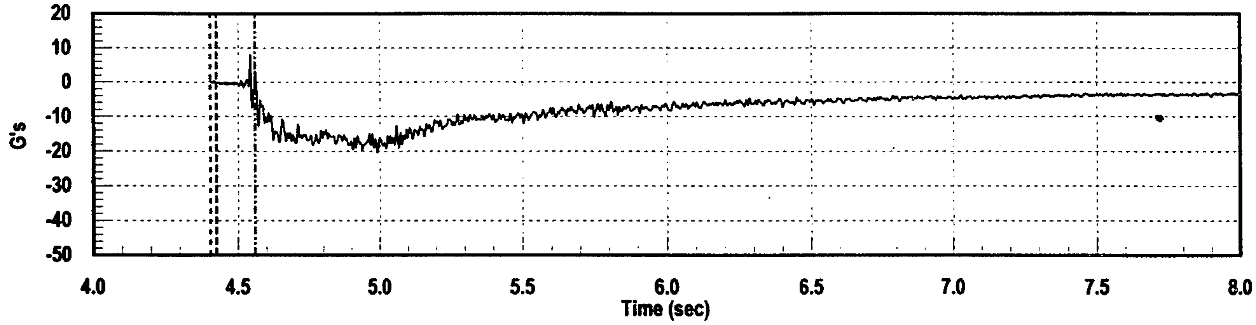
Seat Acceleration Resultant A



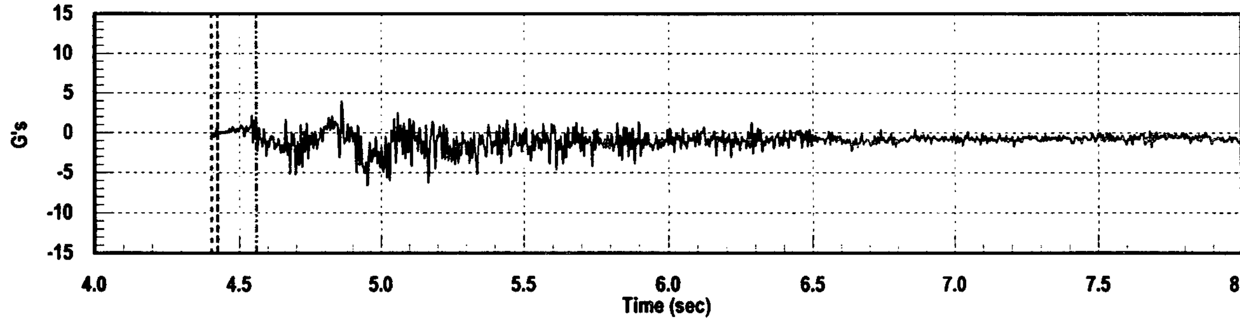
B-1

FL110005, 545 KEAS, 19,000 Ft

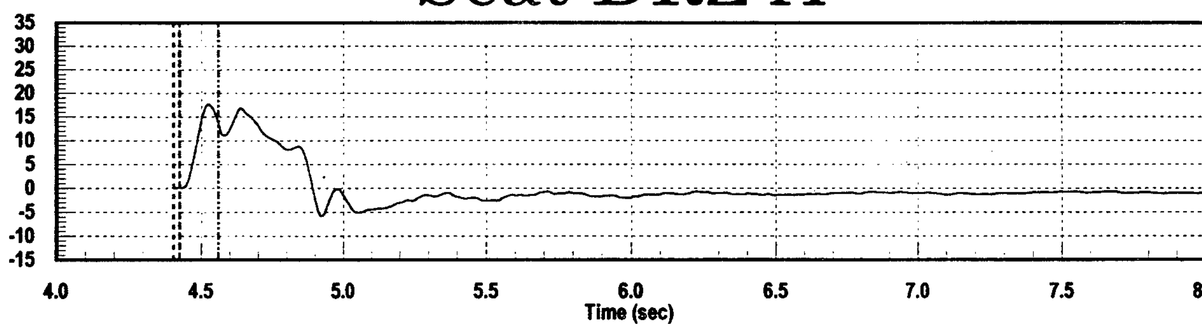
Seat Acceleration AX



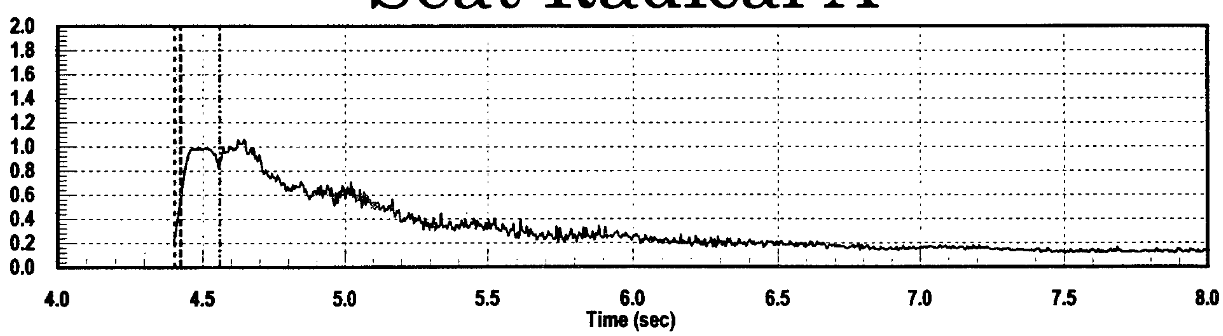
Seat Acceleration AY



Seat DRZ A



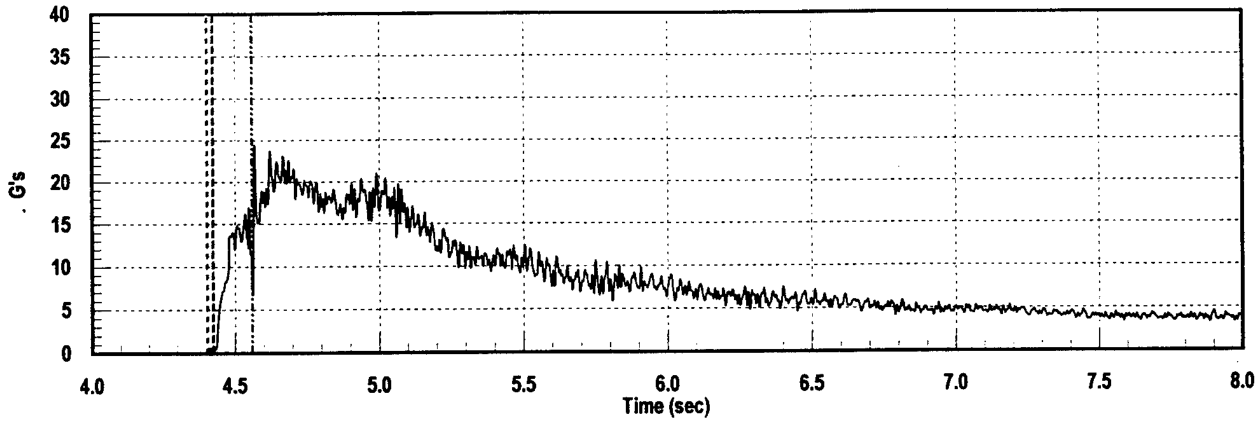
Seat Radical A



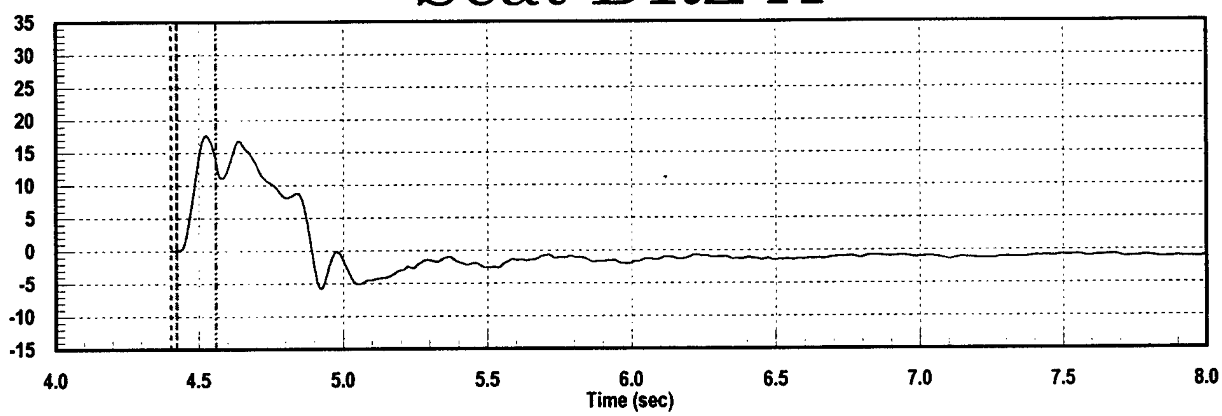
B-2

FL110005, 545 KEAS, 19,000 Ft

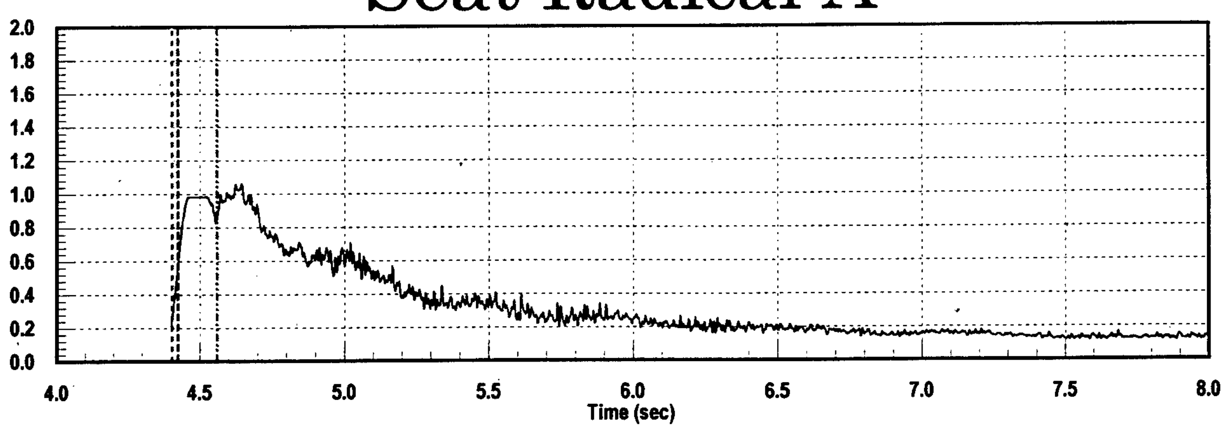
Seat Resultant A



Seat DRZ A



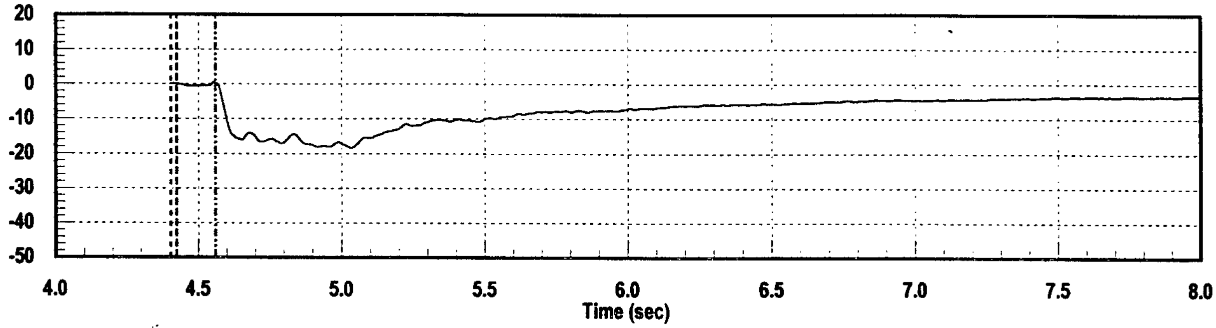
Seat Radical A



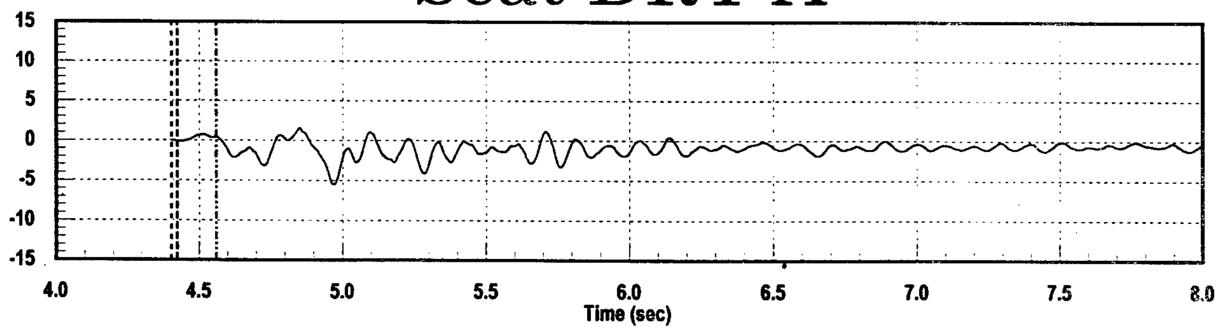
B-3

FL110005, 545 KEAS, 19,000 Ft

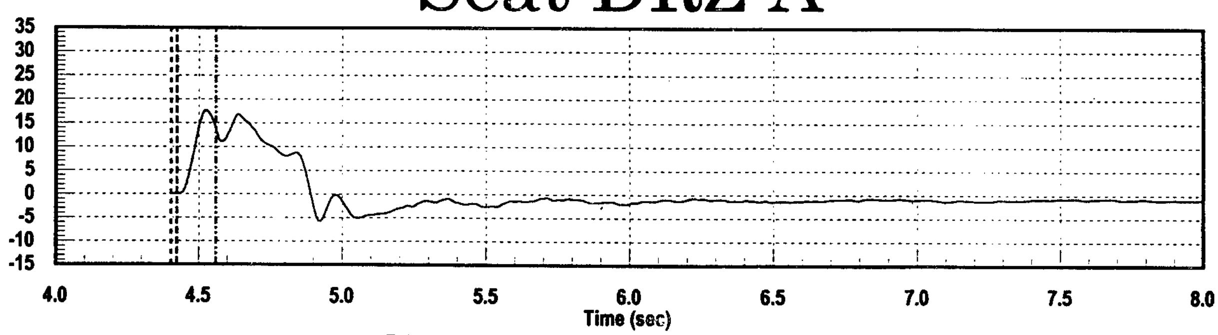
Seat DRX A



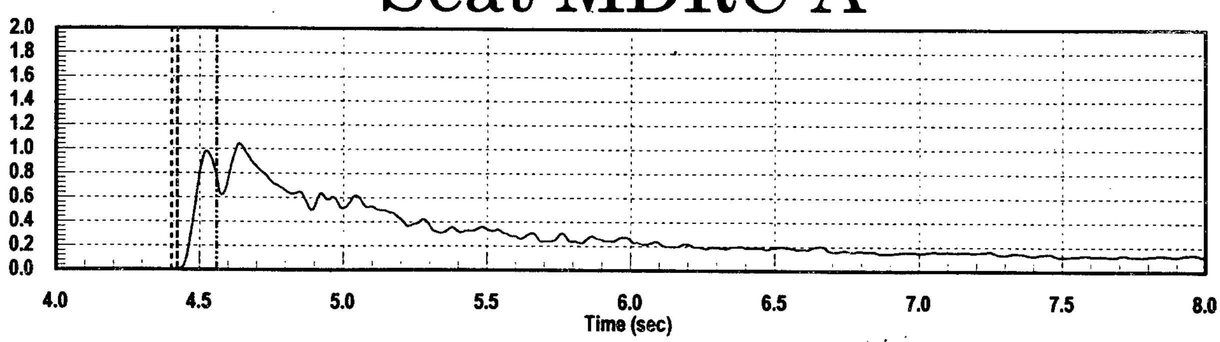
Seat DRY A



Seat DRZ A



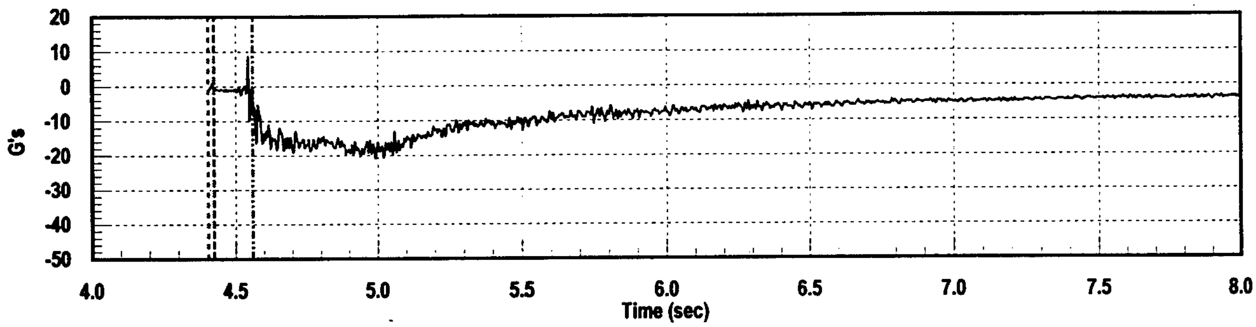
Seat MDRC A



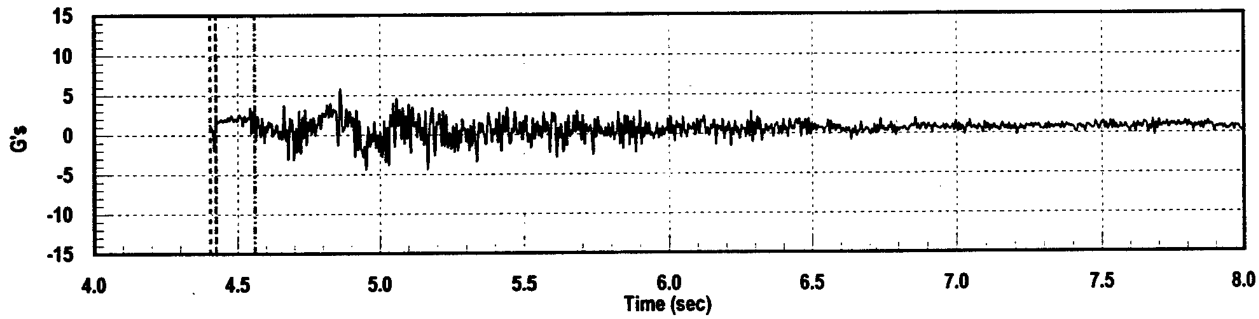
B-4

FL110005, 545 KEAS, 19,000 Ft

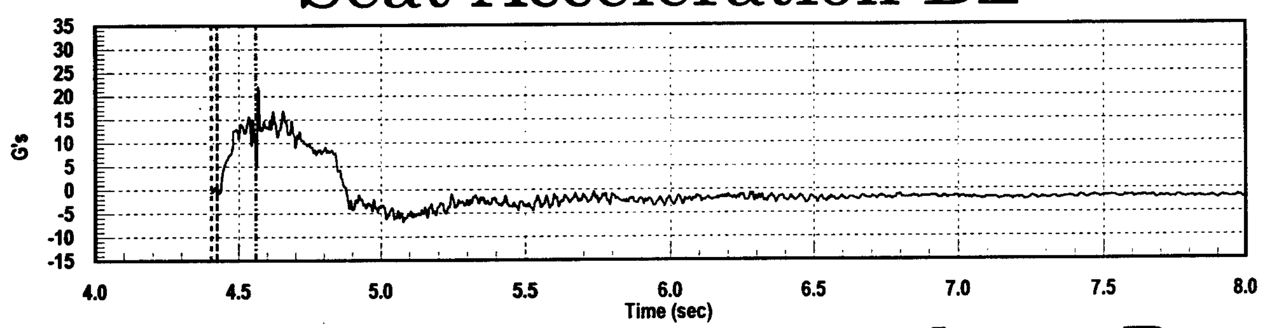
Seat Acceleration BX



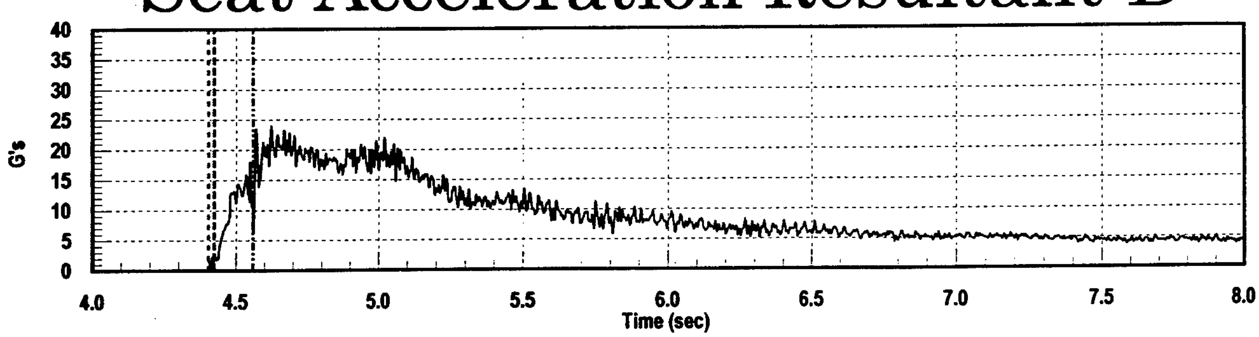
Seat Acceleration BY



Seat Acceleration BZ

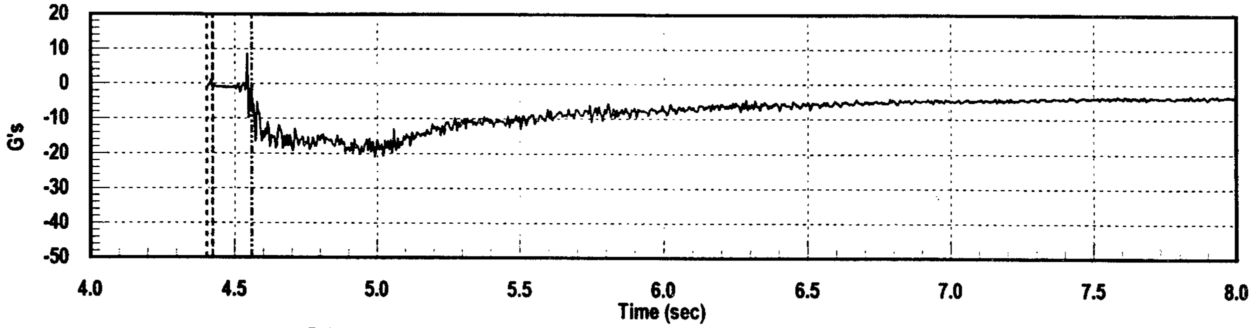


Seat Acceleration Resultant B

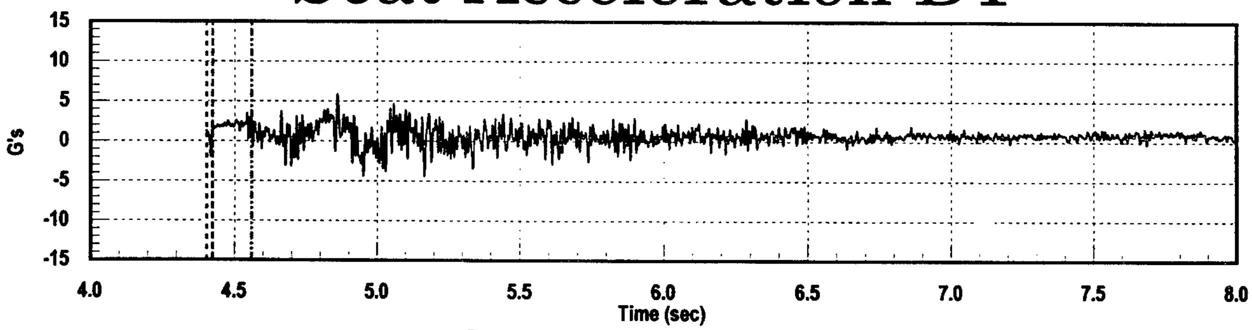


FL110005, 545 KEAS, 19,000 Ft

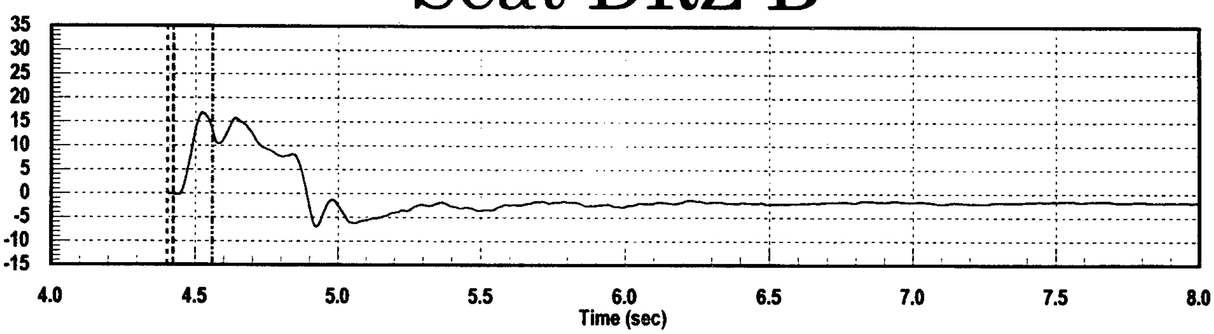
Seat Acceleration BX



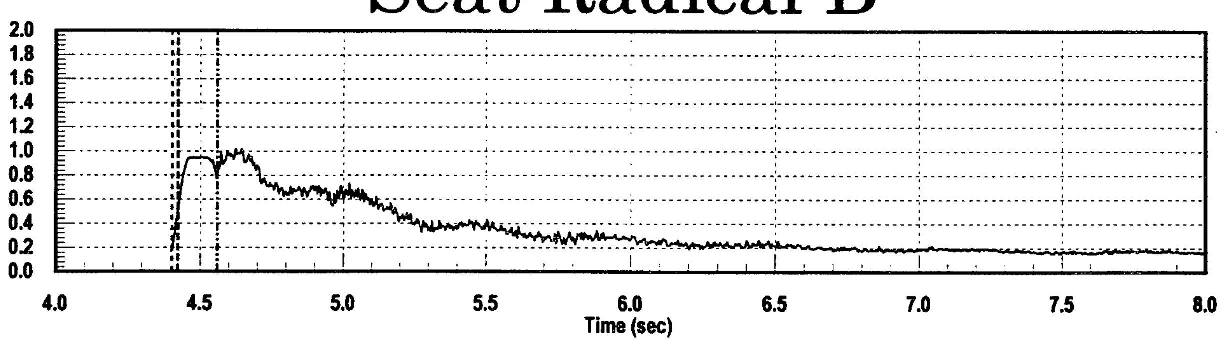
Seat Acceleration BY



Seat DRZ B



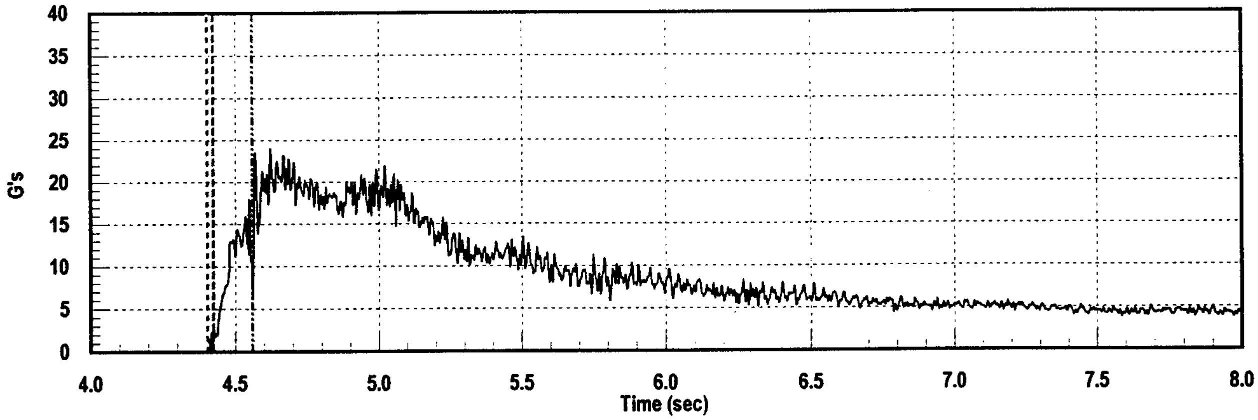
Seat Radical B



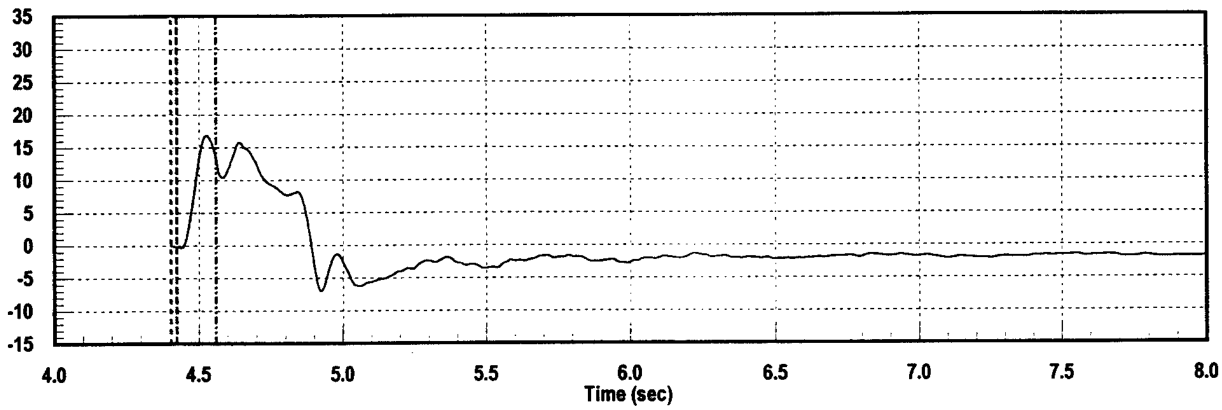
B-6

FL110005, 545 KEAS, 19,000 Ft

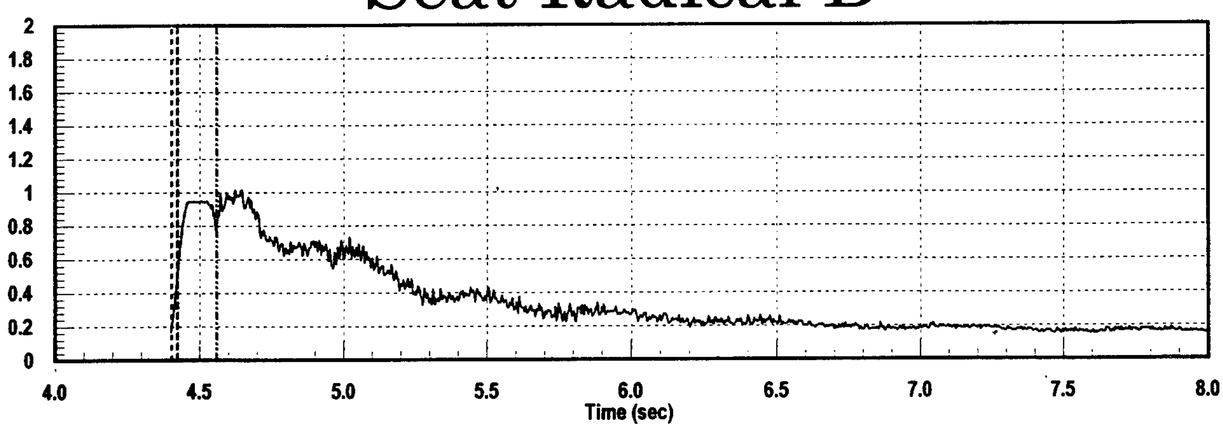
Seat Resultant B



Seat DRZ B



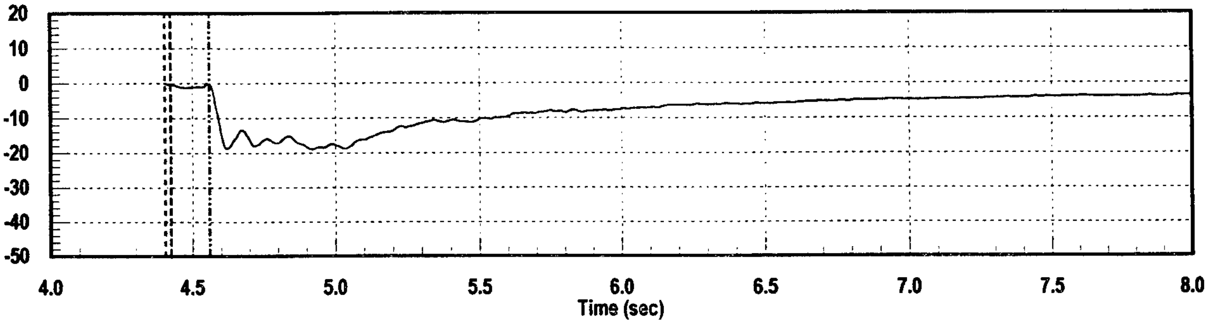
Seat Radical B



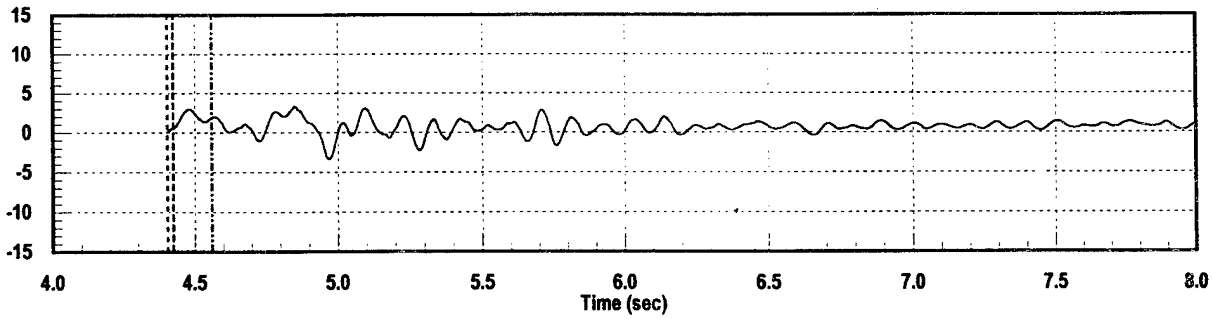
B-7

FL110005, 545 KEAS, 19,000 Ft

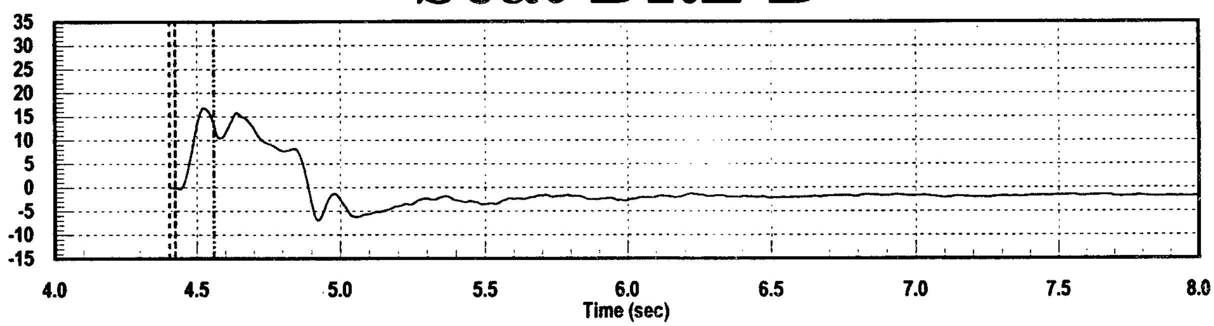
Seat DRX B



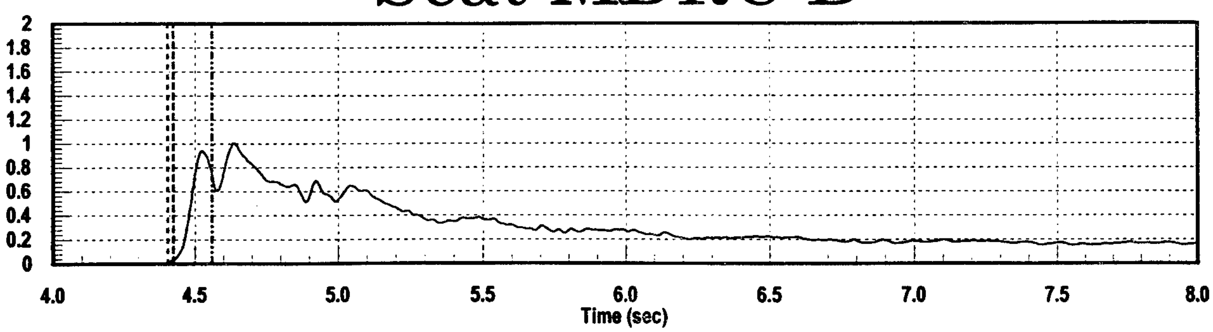
Seat DRY B



Seat DRZ B



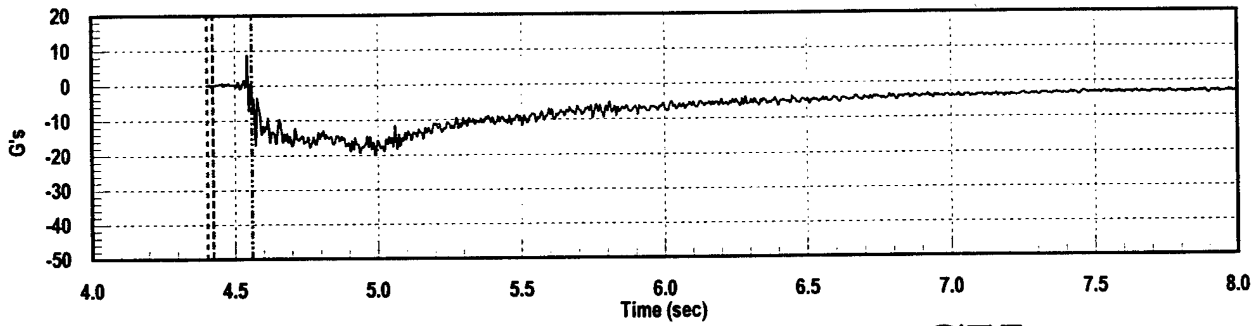
Seat MDRC B



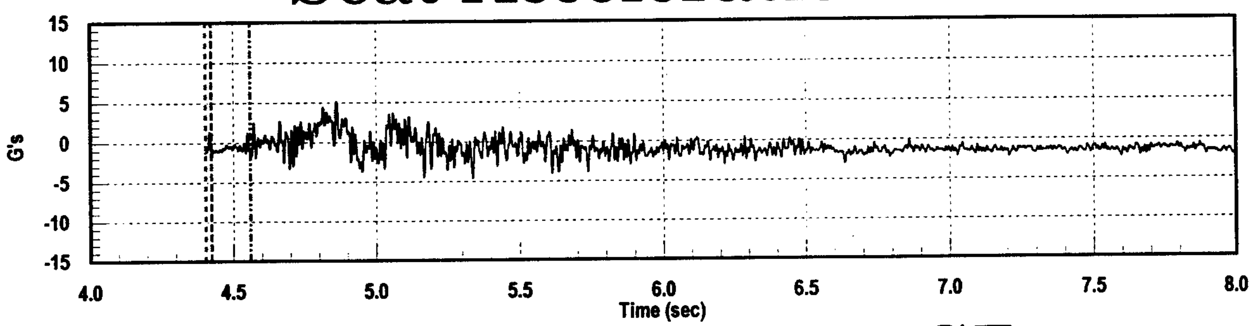
B-8

FL110005, 545 KEAS, 19,000 Ft

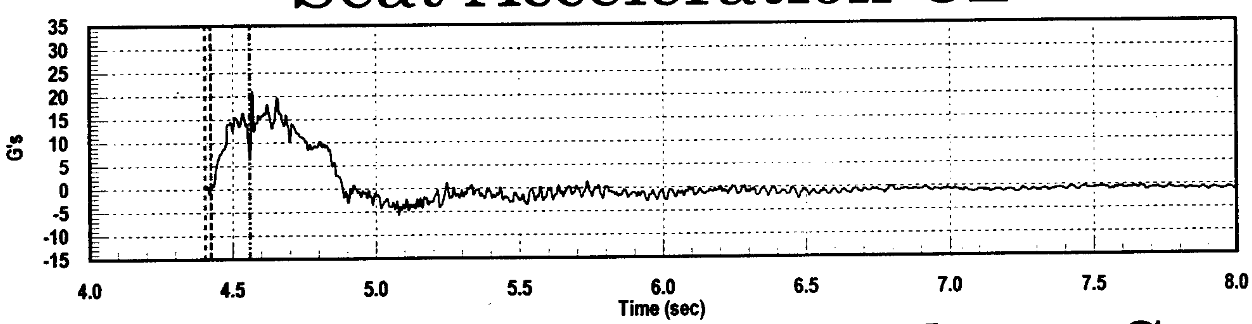
Seat Acceleration CX



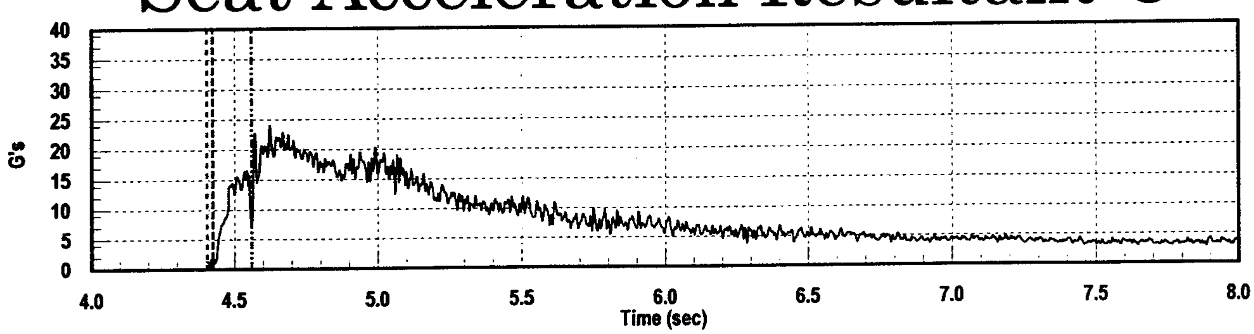
Seat Acceleration CY



Seat Acceleration CZ

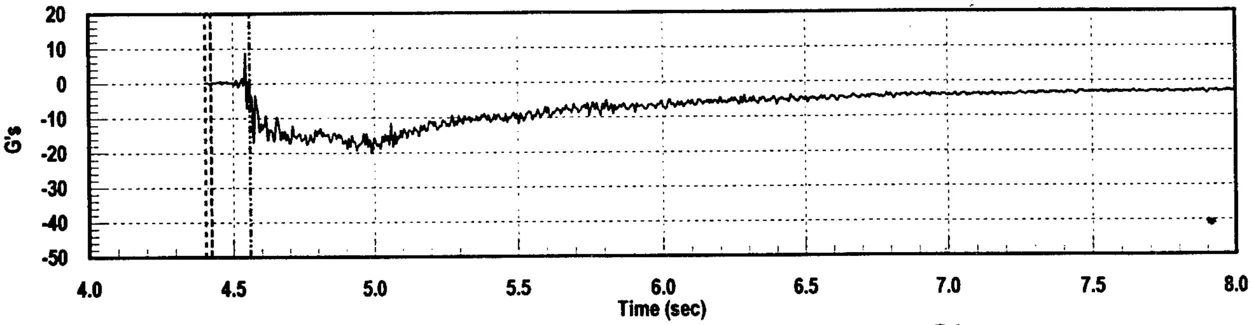


Seat Acceleration Resultant C

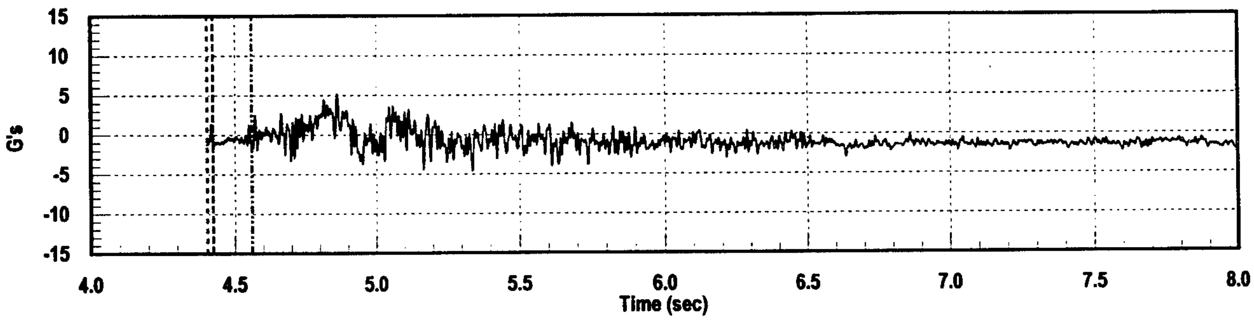


FL110005, 545 KEAS, 19,000 Ft

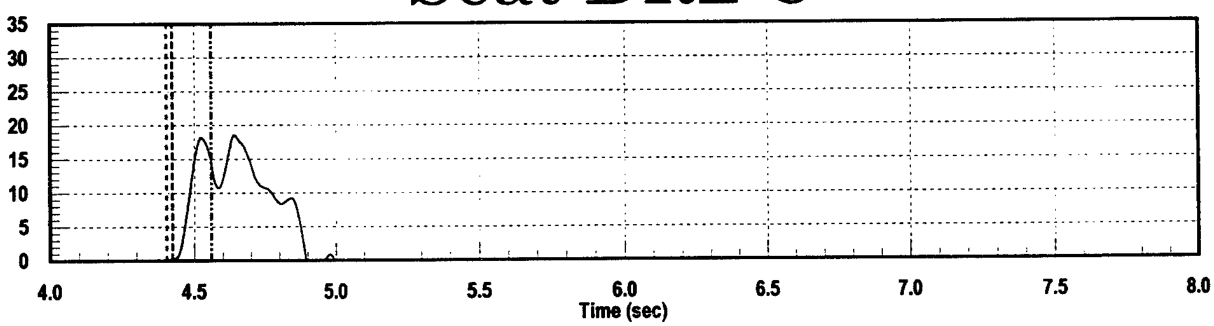
Seat Acceleration CX



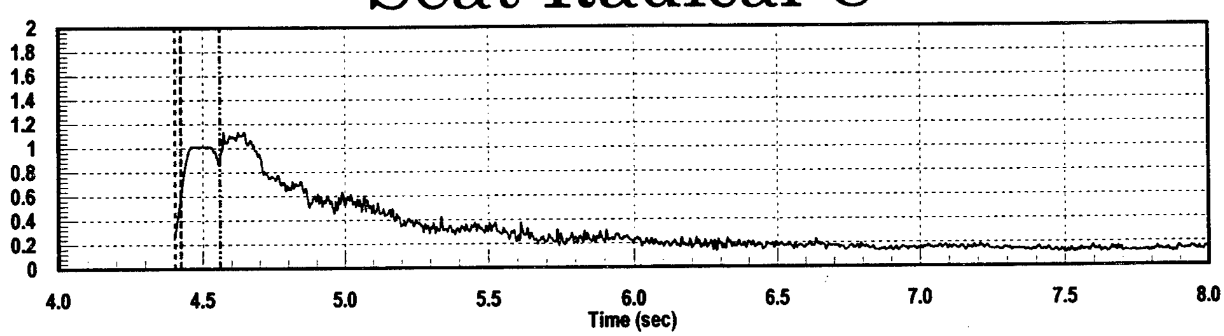
Seat Acceleration CY



Seat DRZ C



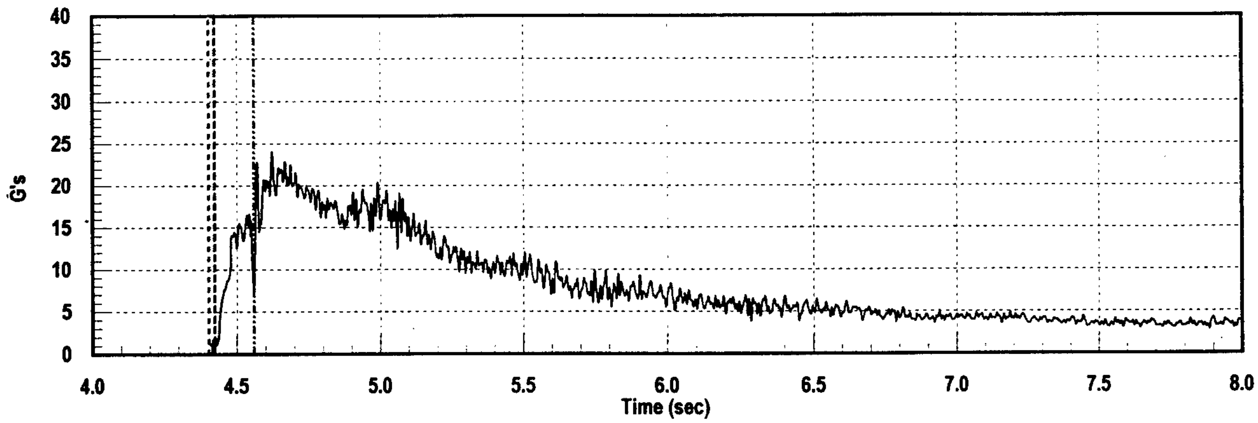
Seat Radical C



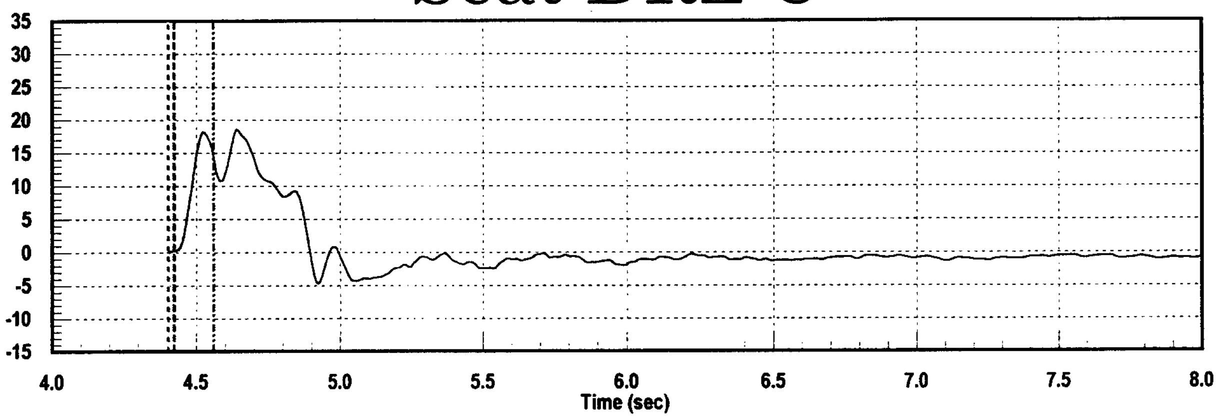
B-10

FL110005, 545 KEAS, 19,000 Ft

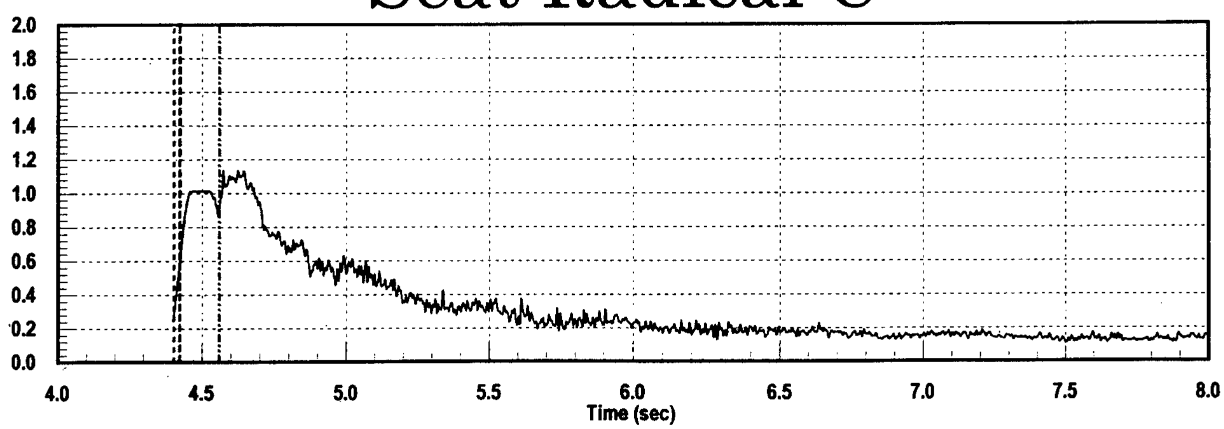
Seat Resultant C



Seat DRZ C



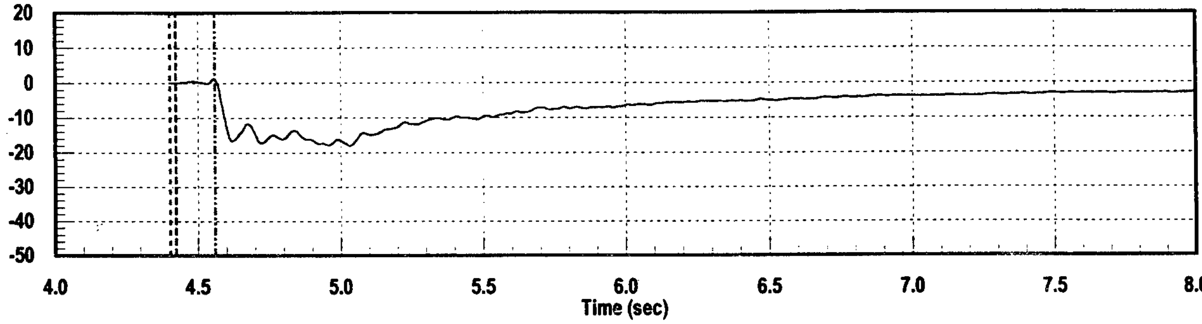
Seat Radical C



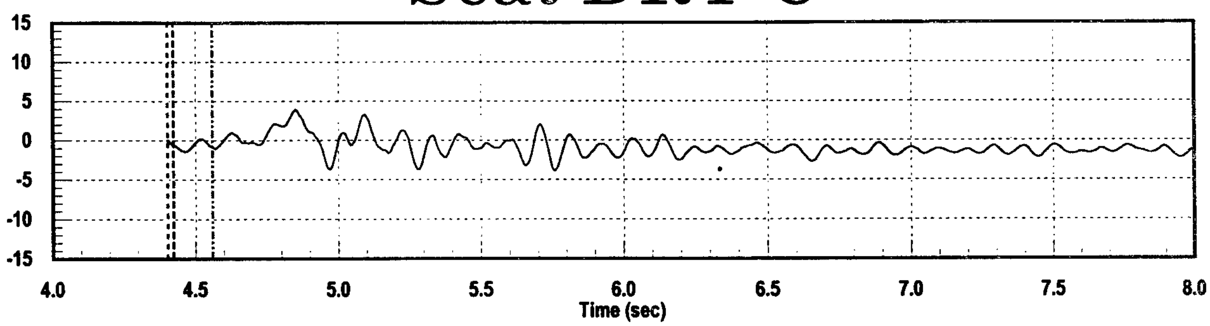
B-11

FL110005, 545 KEAS, 19,000 Ft

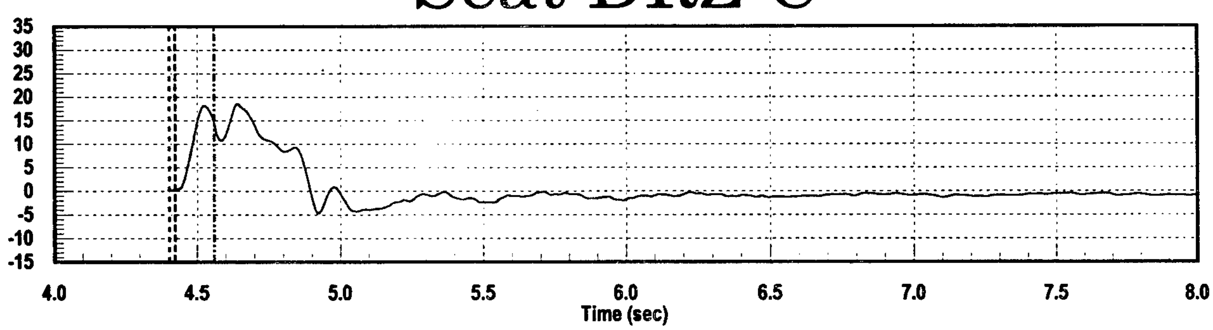
Seat DRX C



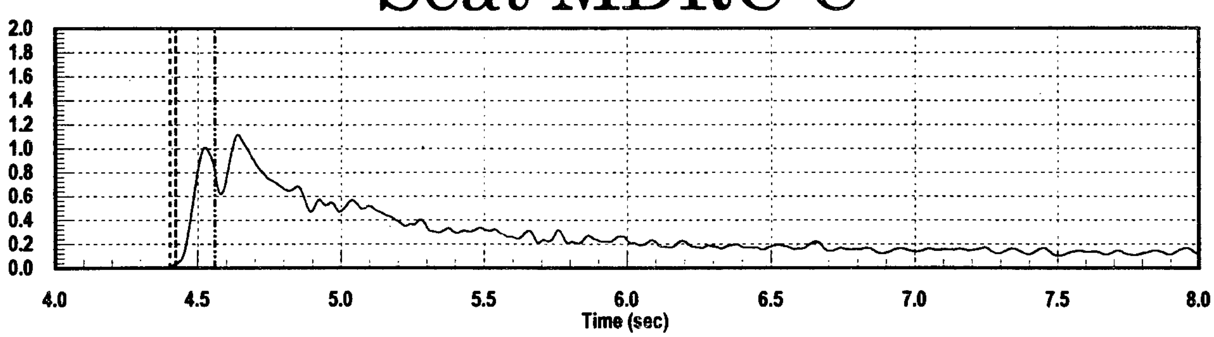
Seat DRY C



Seat DRZ C

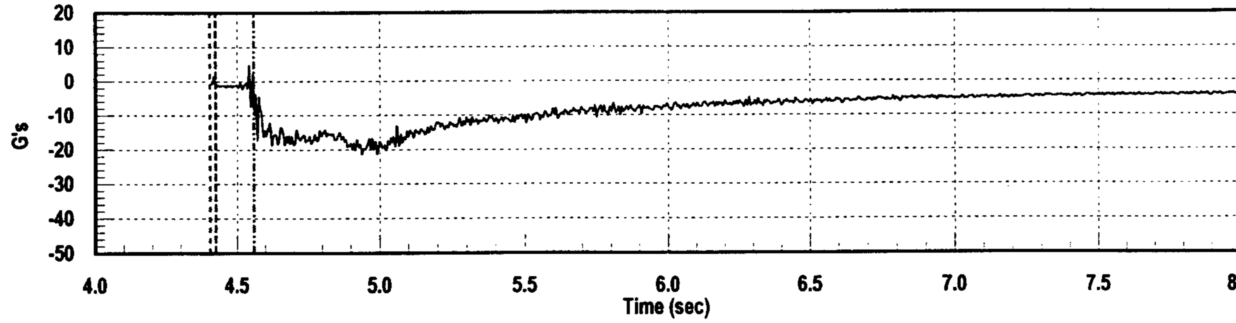


Seat MDRC C

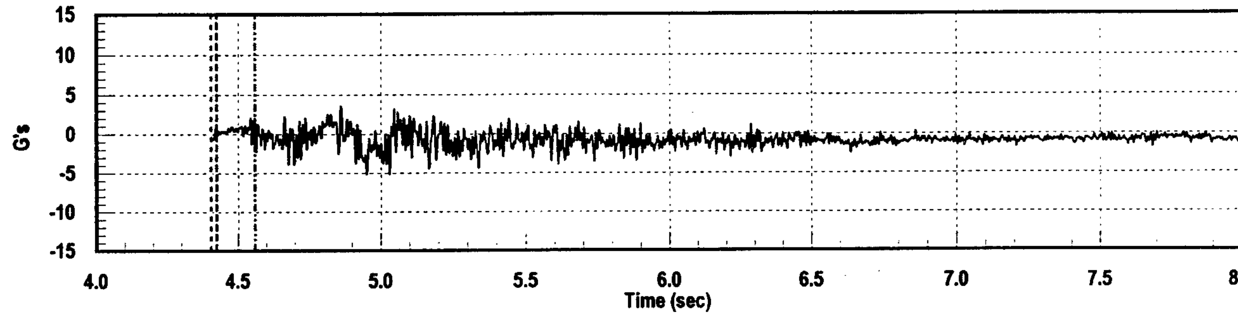


FL110005, 545 KEAS, 19,000 Ft

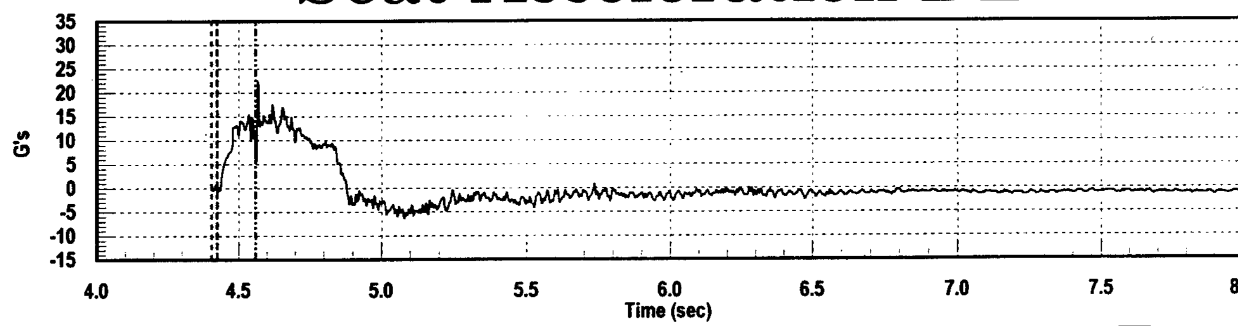
Seat Acceleration DX



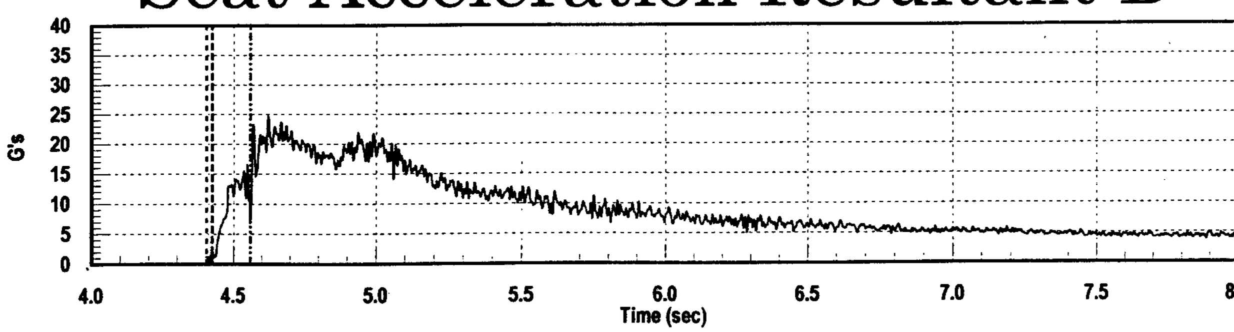
Seat Acceleration DY



Seat Acceleration DZ



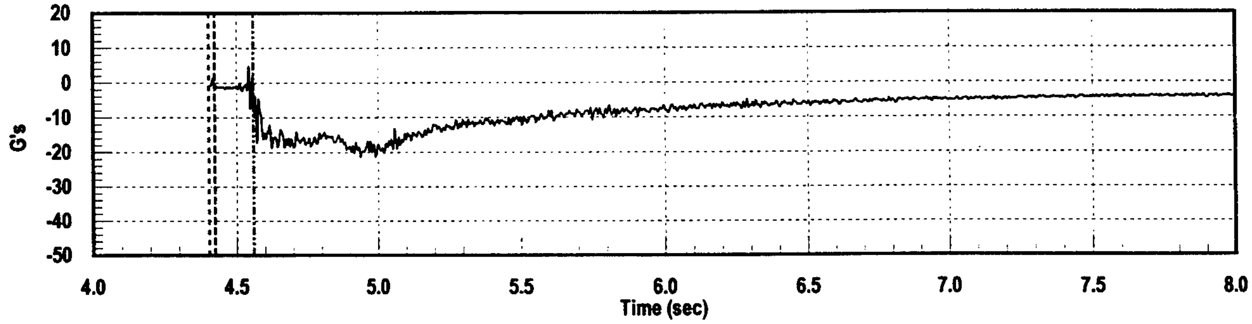
Seat Acceleration Resultant D



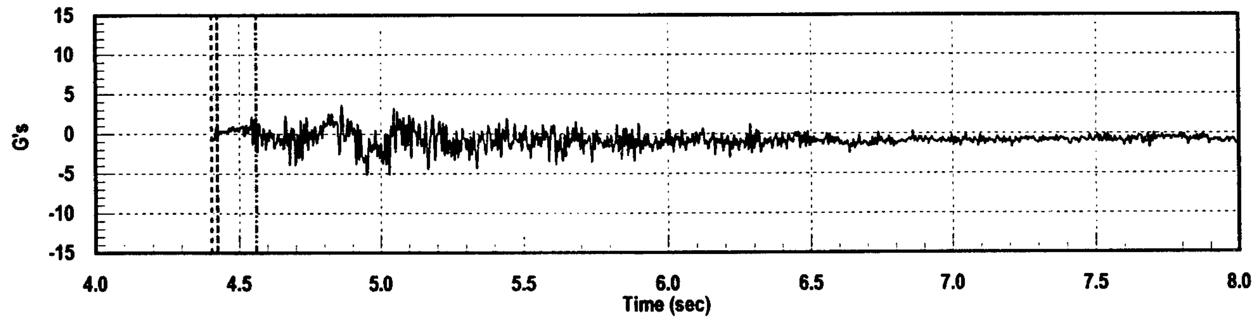
B-13

FL110005, 545 KEAS, 19,000 Ft

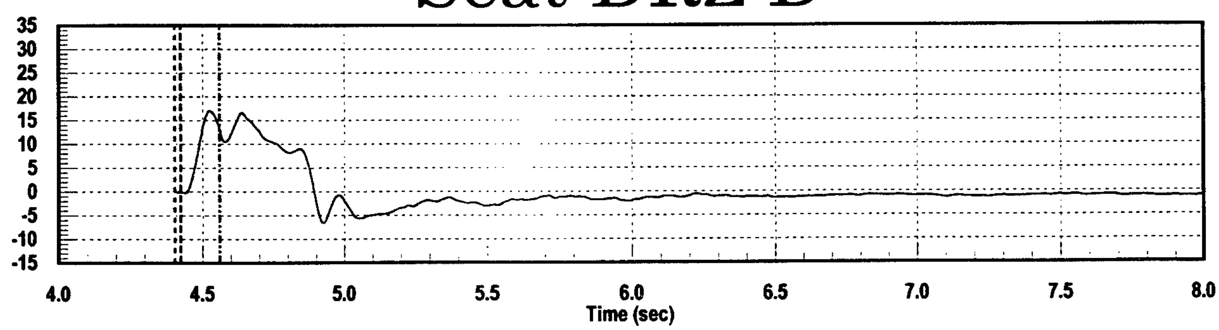
Seat Acceleration DX



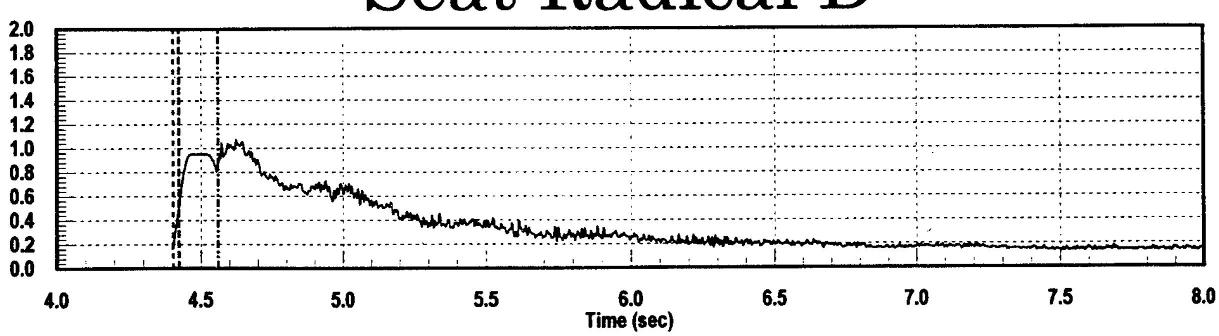
Seat Acceleration DY



Seat DRZ D



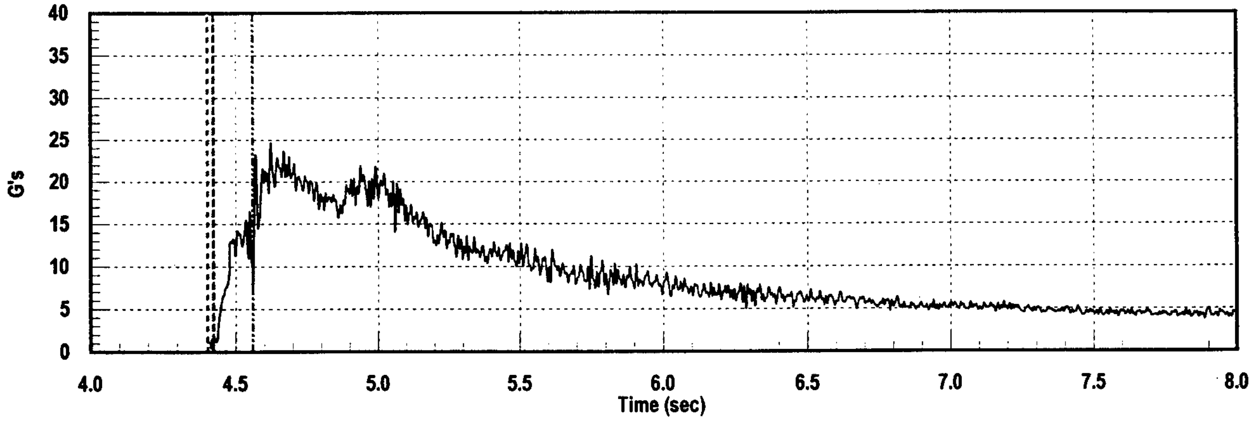
Seat Radical D



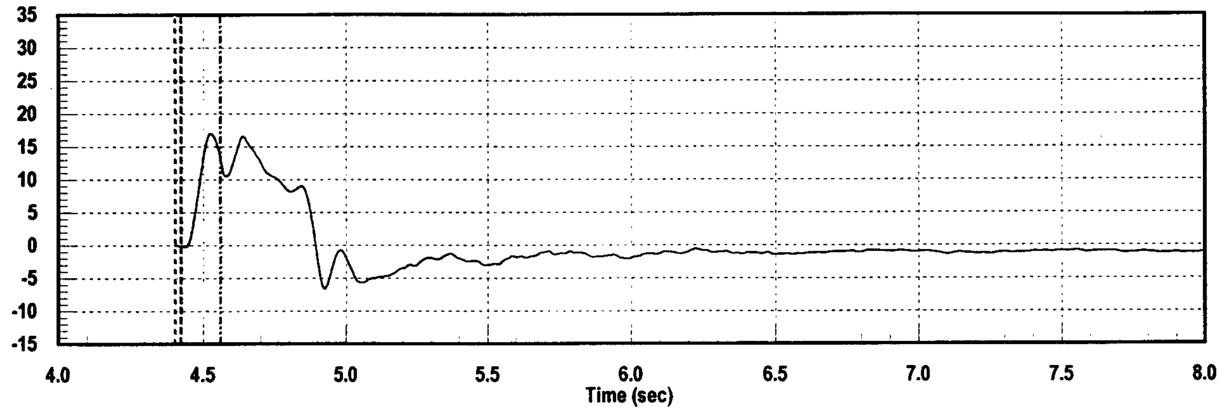
B-14

FL110005, 545 KEAS, 19,000 Ft

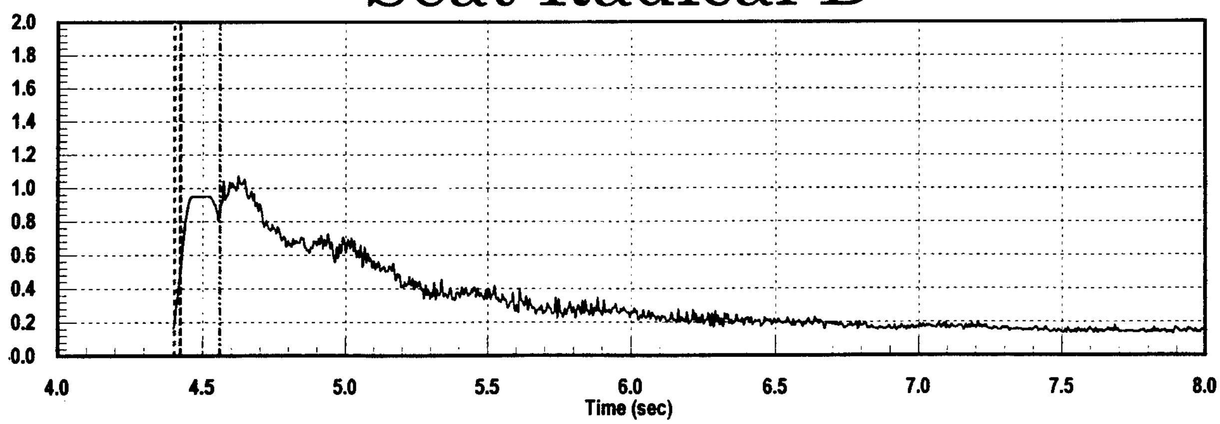
Seat Resultant D



Seat DRZ D



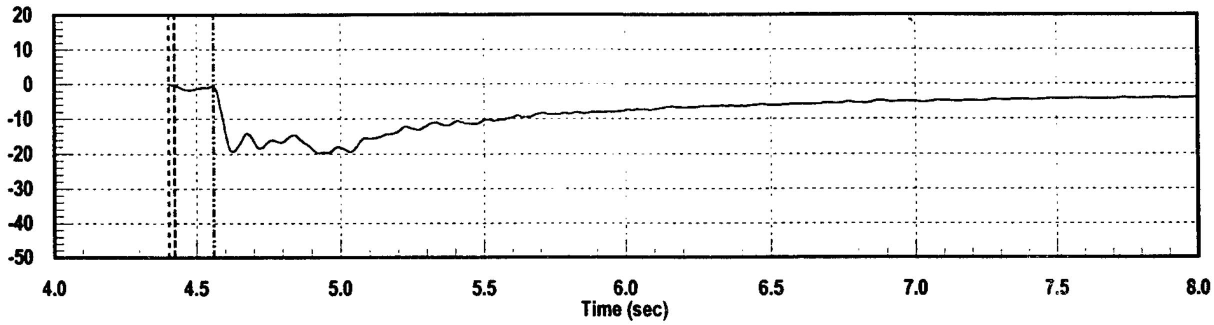
Seat Radical D



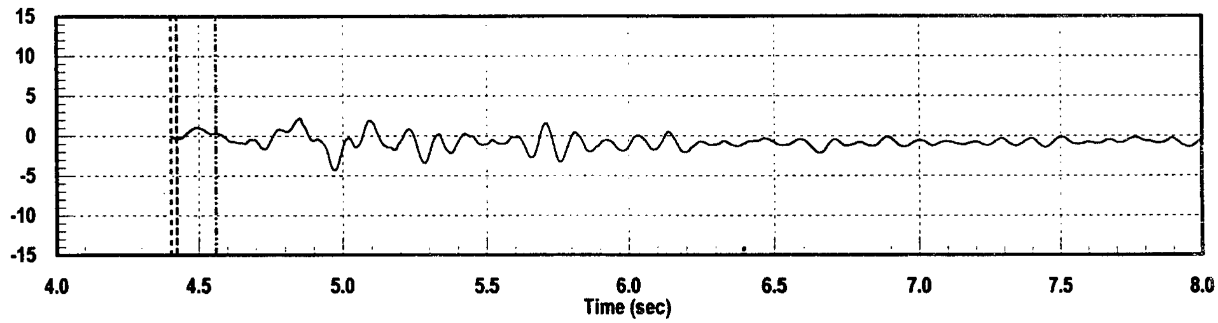
B-15

FL110005, 545 KEAS, 19,000 Ft

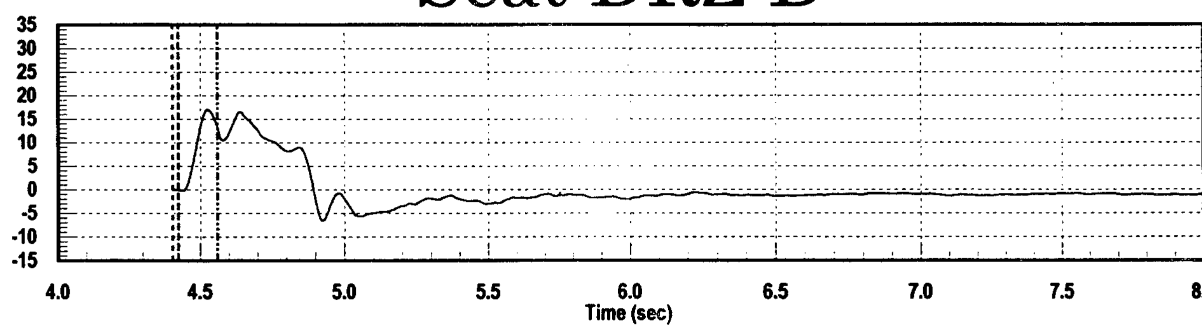
Seat DRX D



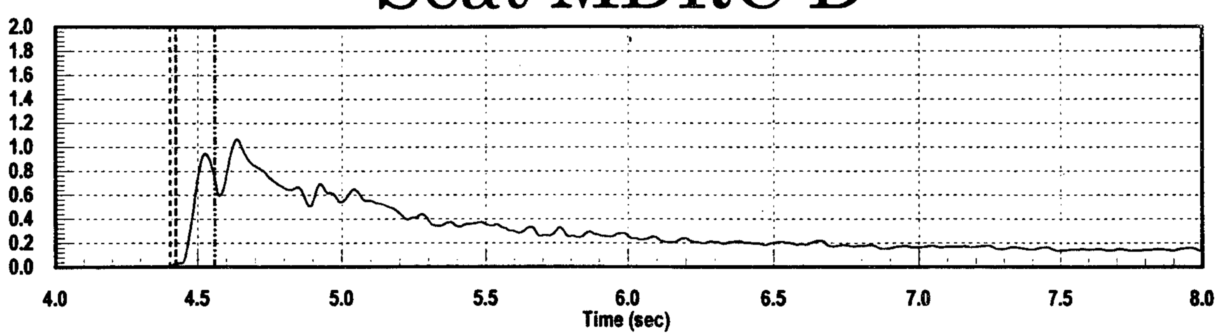
Seat DRY D



Seat DRZ D



Seat MDRC D



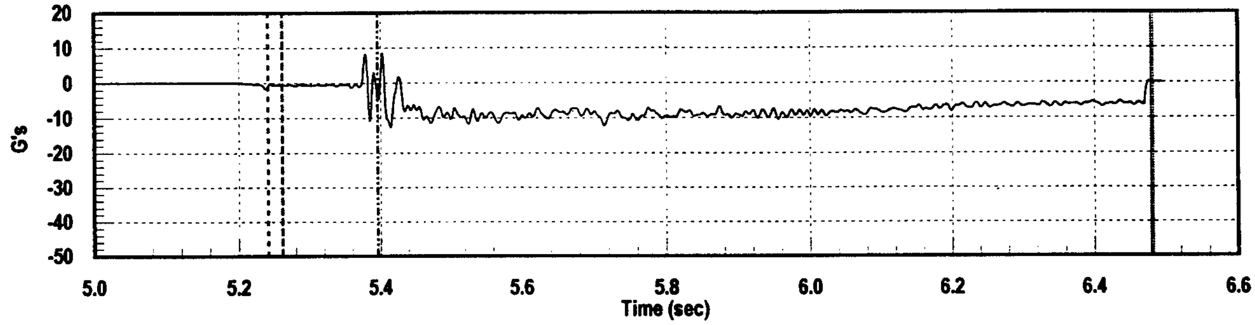
B-16

FL083301, 450 KEAS, 1,200 Ft
Dynamic Response Analysis

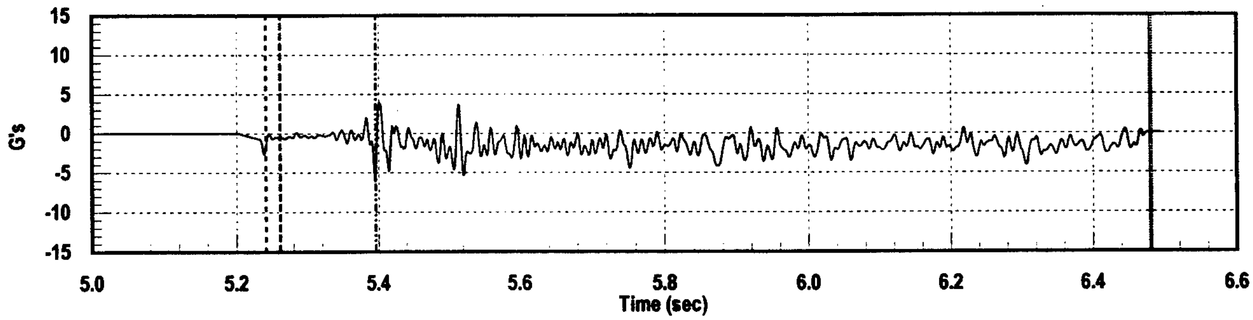
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL083301, 450 KEAS, 1,200 Ft

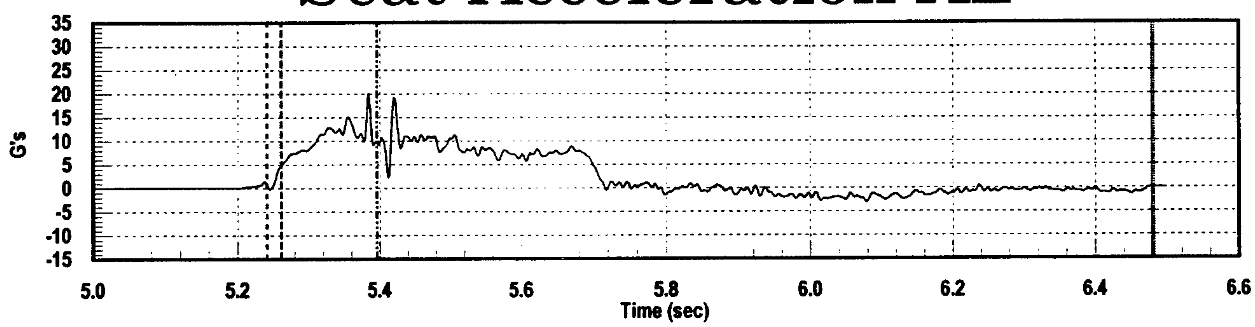
Seat Acceleration AX



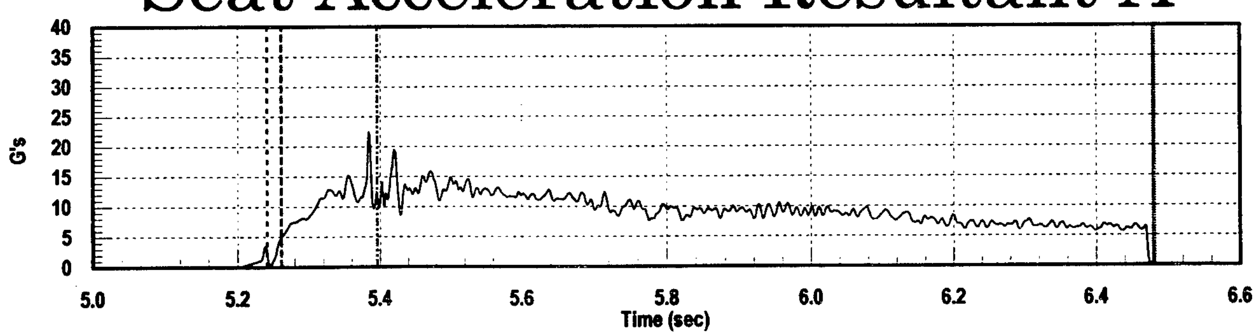
Seat Acceleration AY



Seat Acceleration AZ



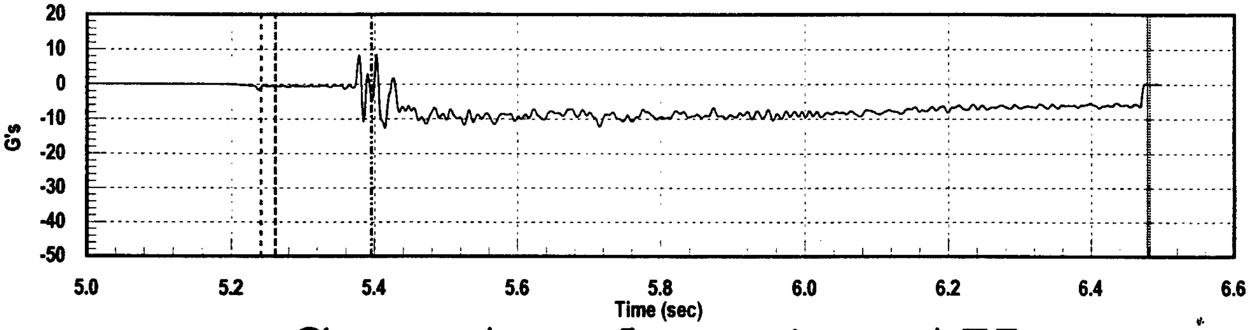
Seat Acceleration Resultant A



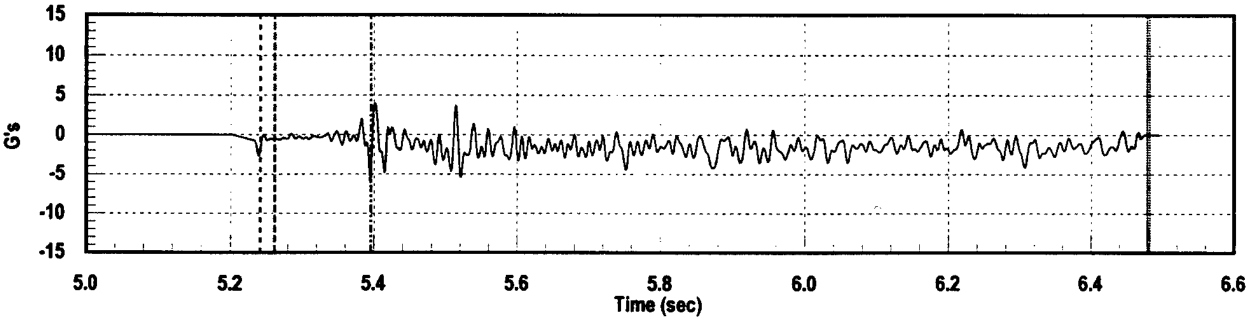
B-1

FL083301, 450 KEAS, 1,200 Ft

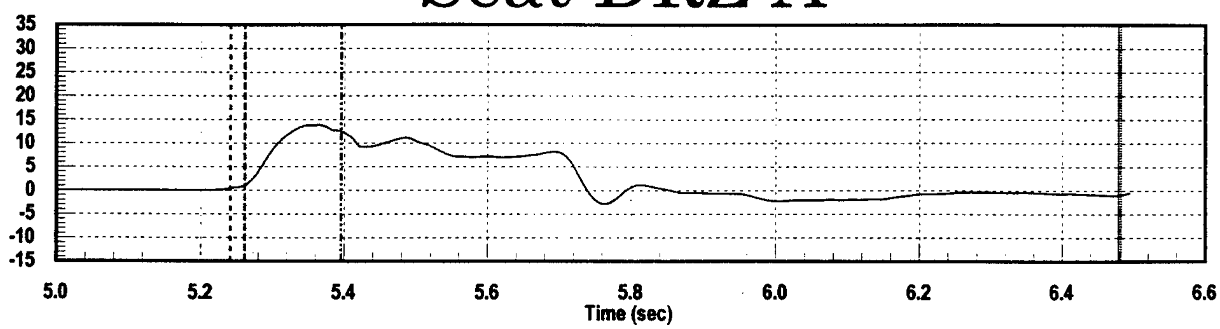
Seat Acceleration AX



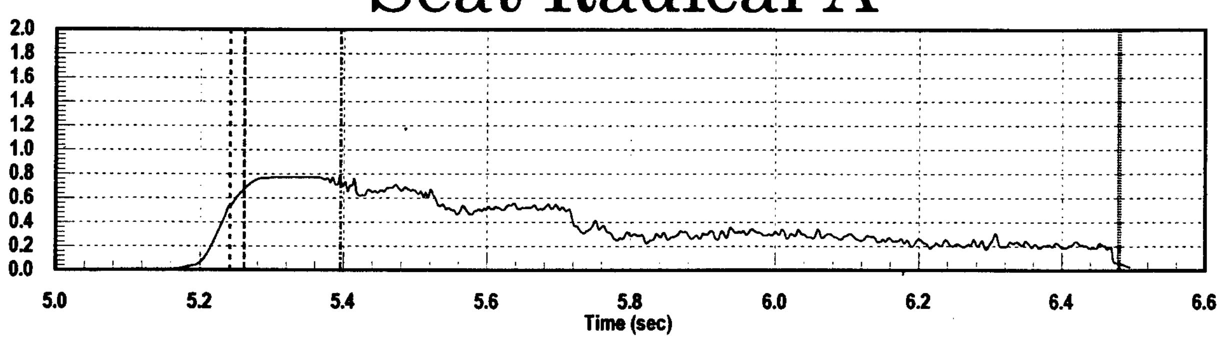
Seat Acceleration AY



Seat DRZ A



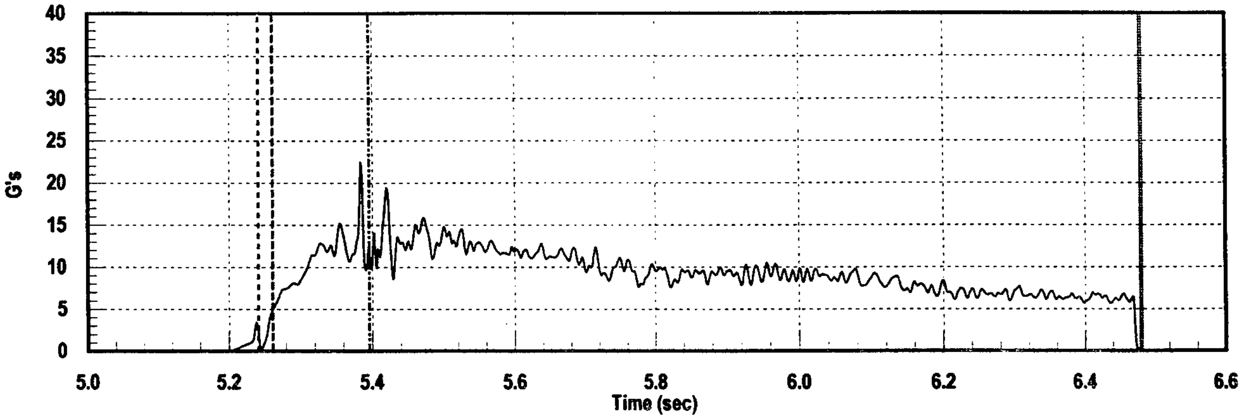
Seat Radical A



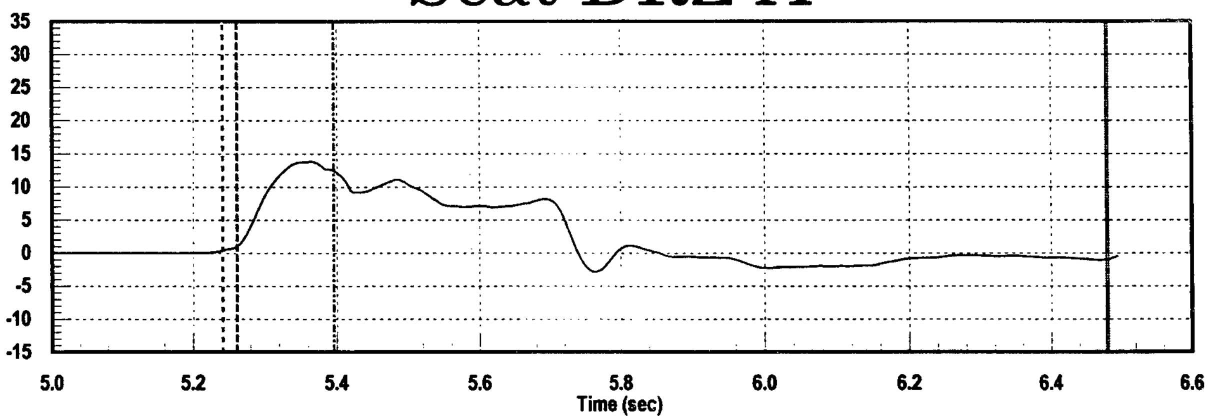
B-2

FL083301, 450 KEAS, 1,200 Ft

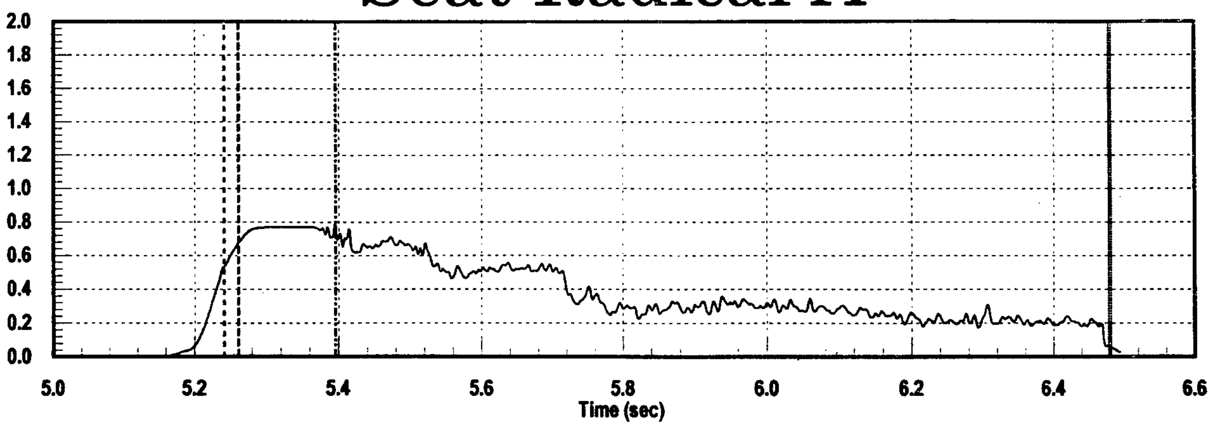
Seat Resultant A



Seat DRZ A



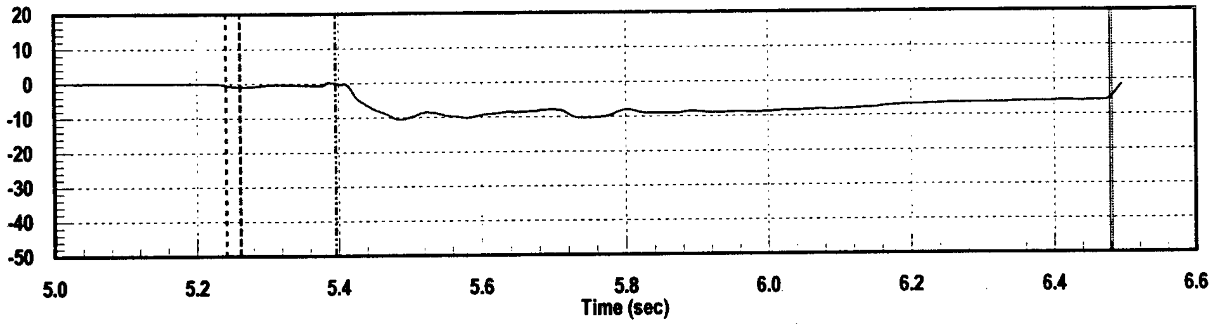
Seat Radical A



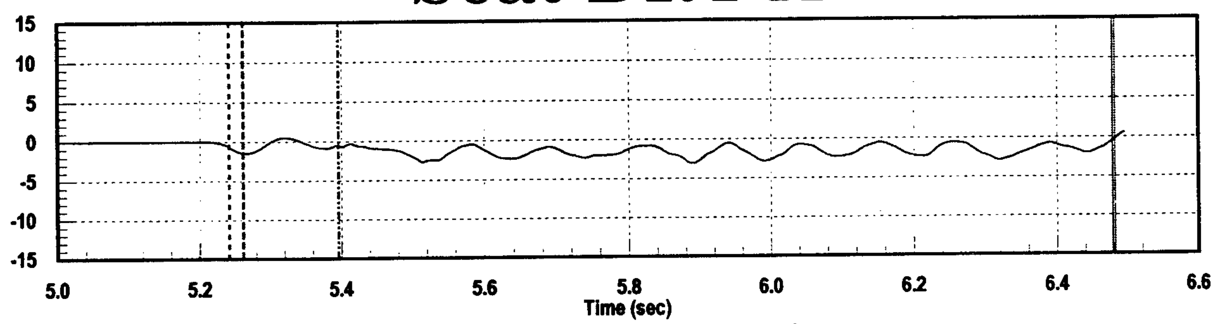
B-3

FL083301, 450 KEAS, 1,200 Ft

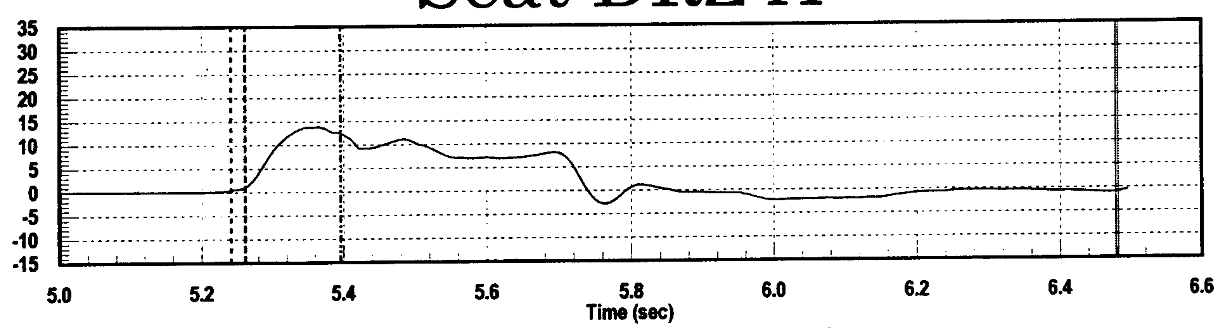
Seat DRX A



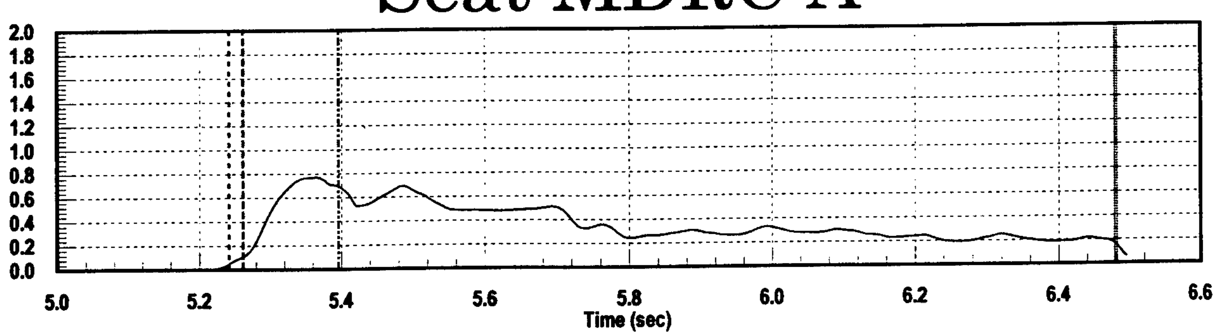
Seat DRY A



Seat DRZ A



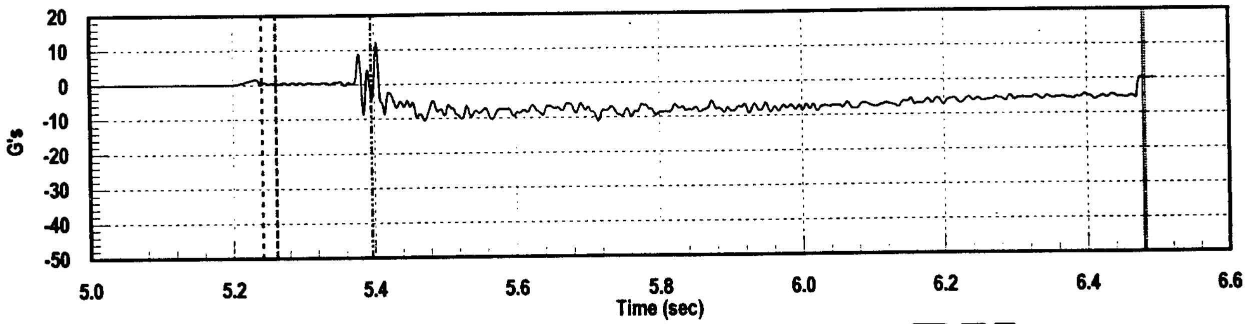
Seat MDRC A



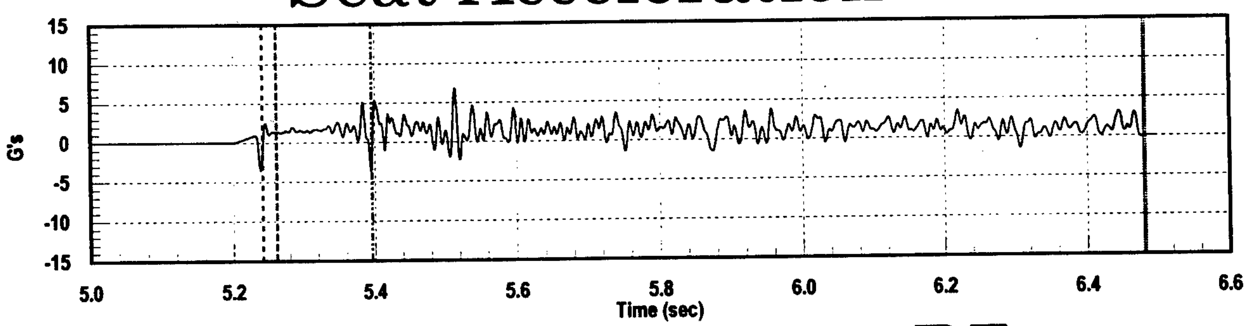
B-4

FL083301, 450 KEAS, 1,200 Ft

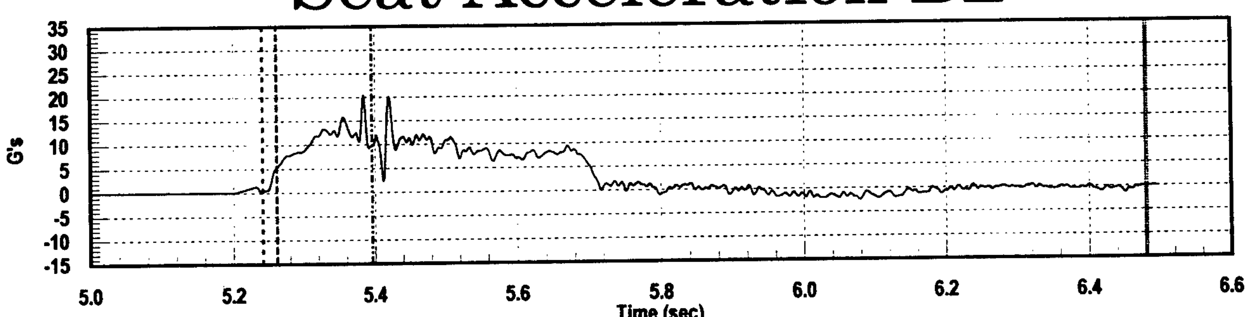
Seat Acceleration BX



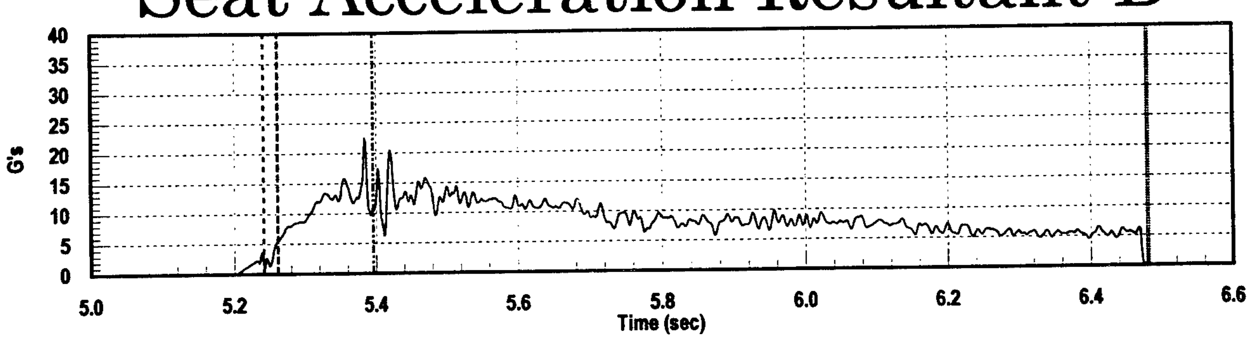
Seat Acceleration BY



Seat Acceleration BZ



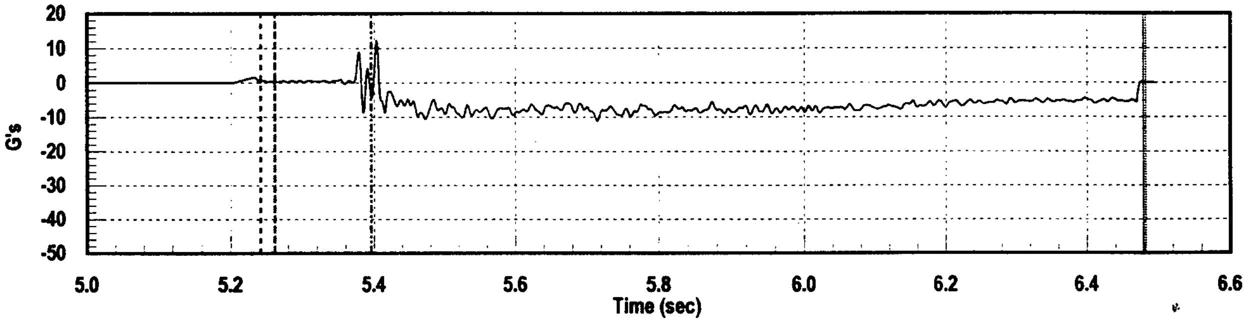
Seat Acceleration Resultant B



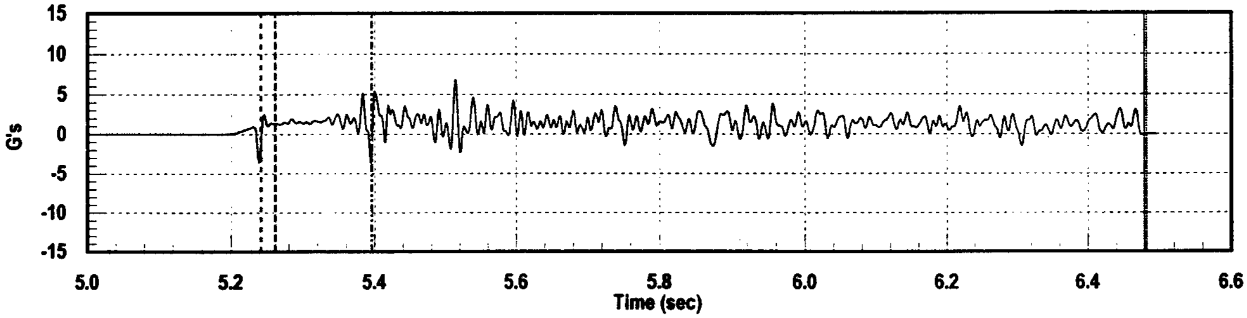
B-5

FL083301, 450 KEAS, 1,200 Ft

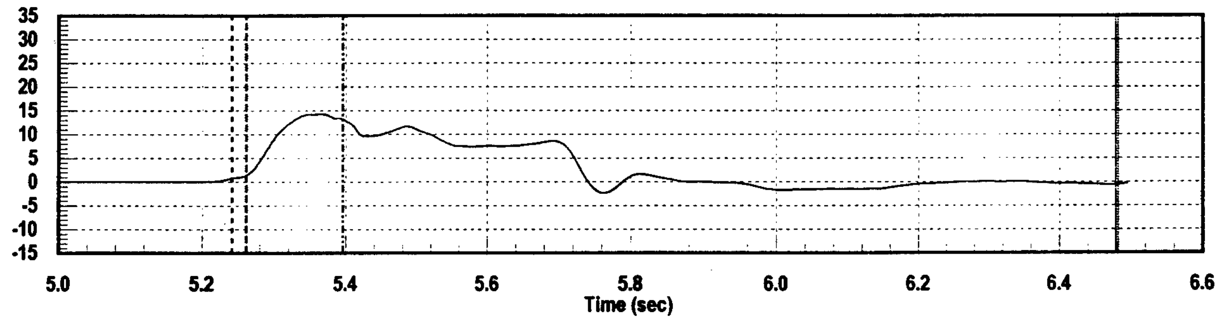
Seat Acceleration BX



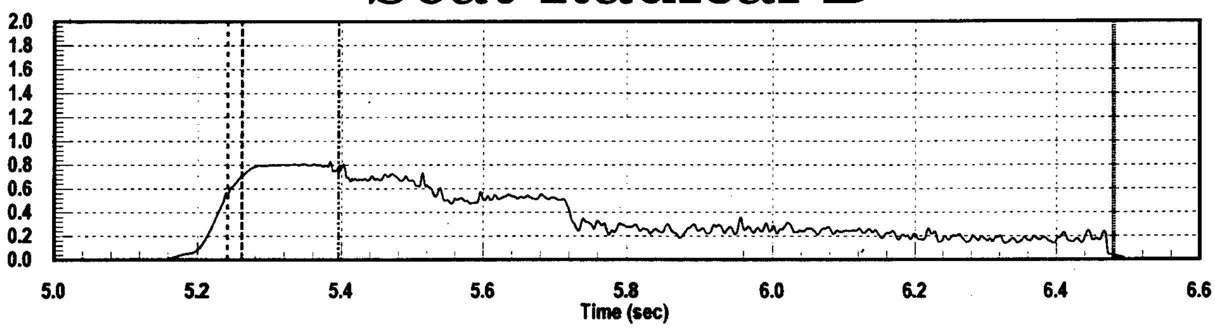
Seat Acceleration BY



Seat DRZ B



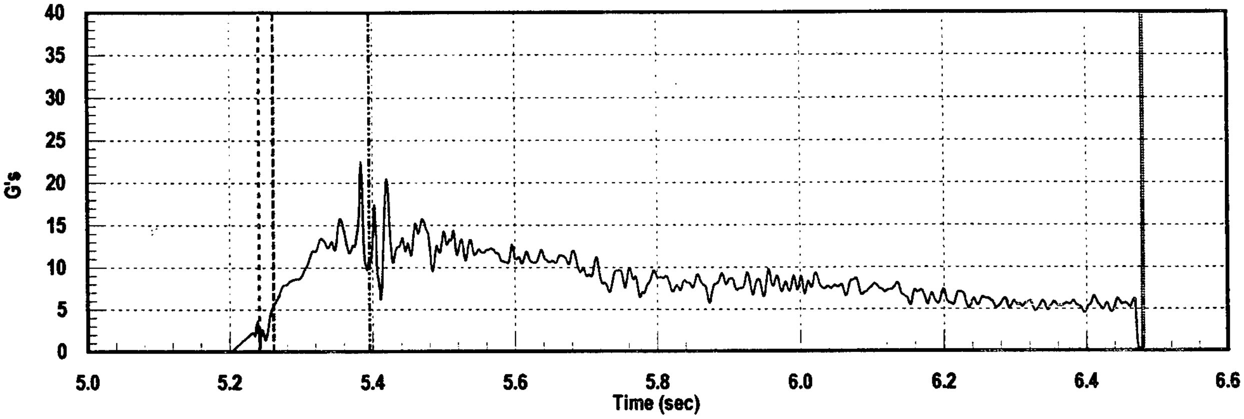
Seat Radical B



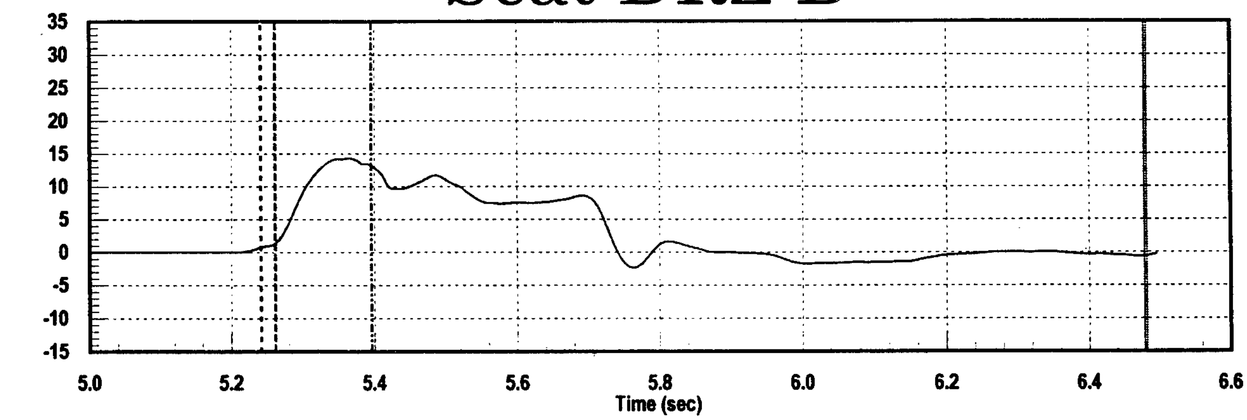
B-6

FL083301, 450 KEAS, 1,200 Ft

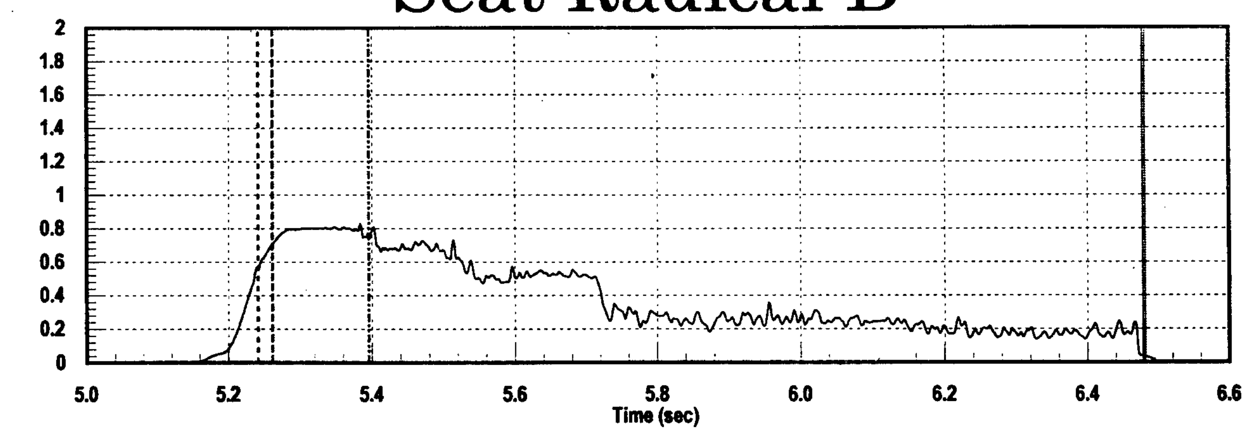
Seat Resultant B



Seat DRZ B



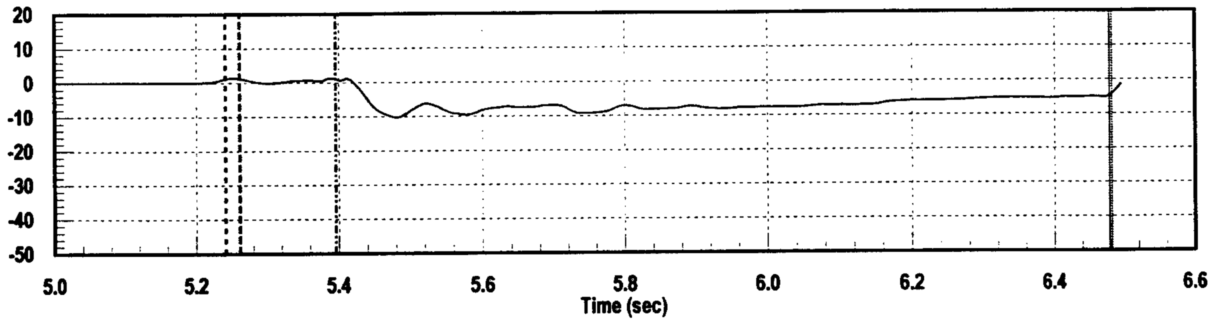
Seat Radical B



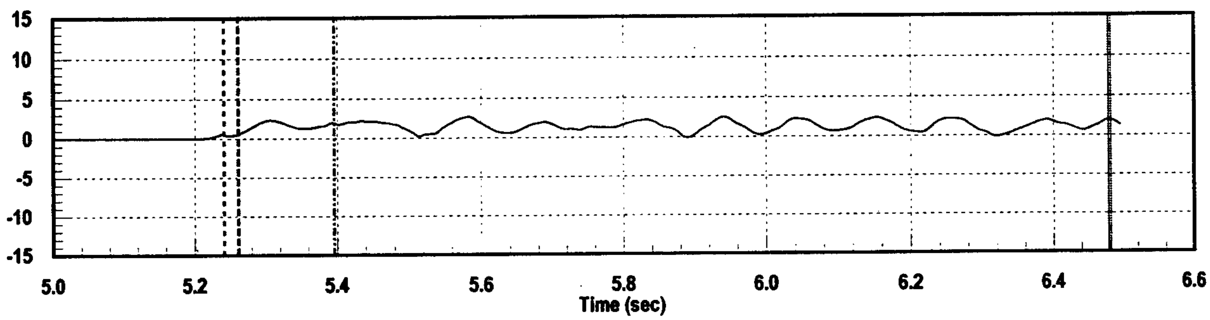
B-7

FL083301, 450 KEAS, 1,200 Ft

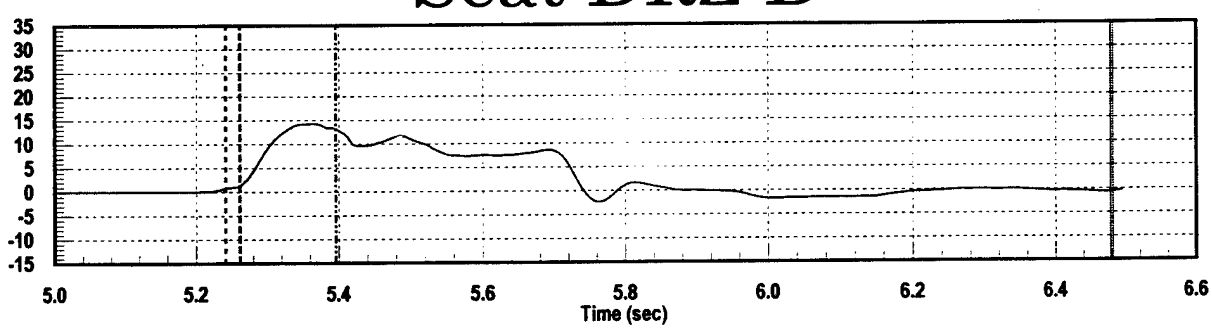
Seat DRX B



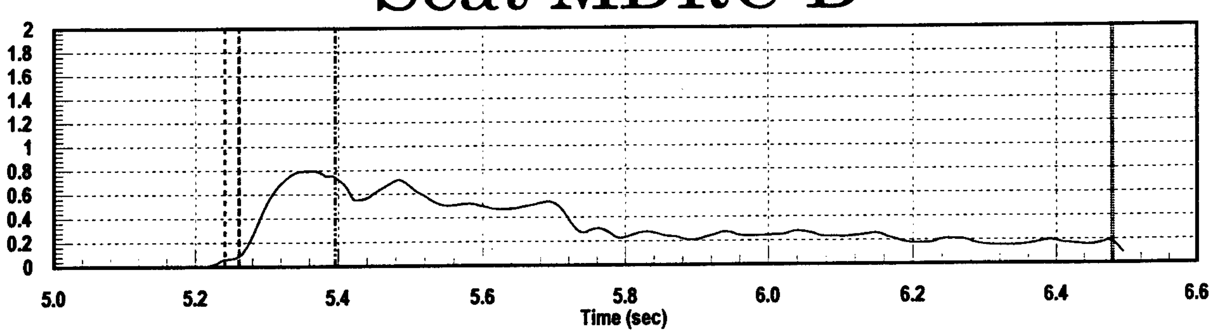
Seat DRY B



Seat DRZ B



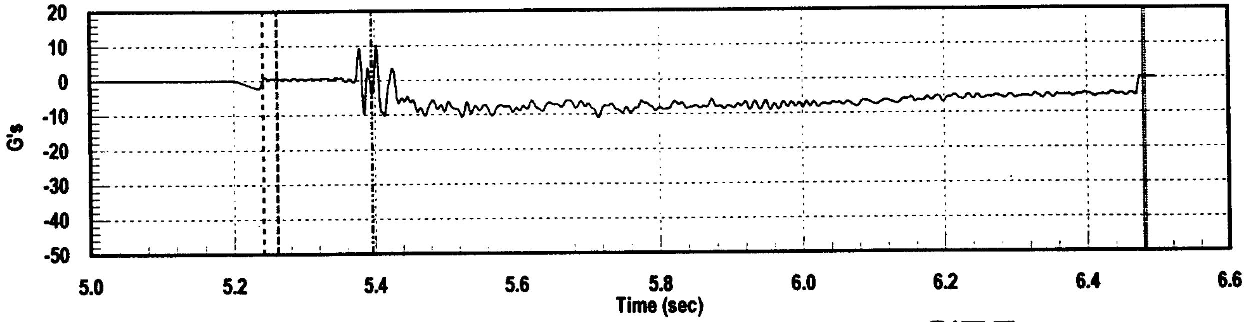
Seat MDRC B



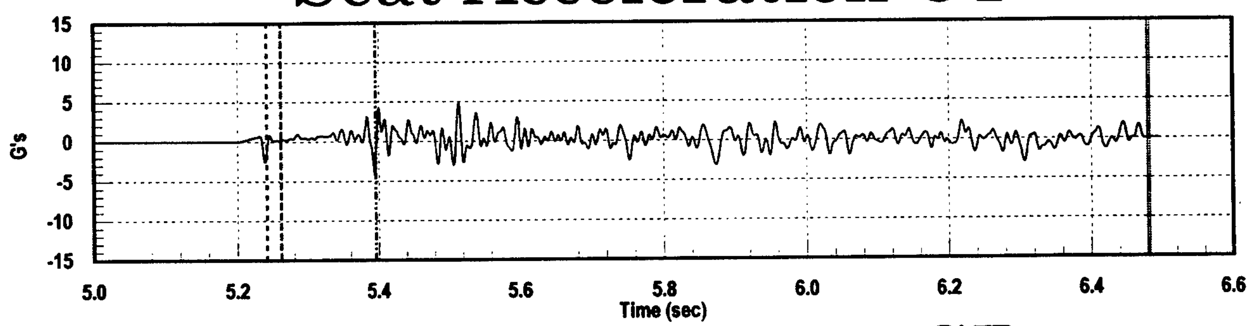
B-8

FL083301, 450 KEAS, 1,200 Ft

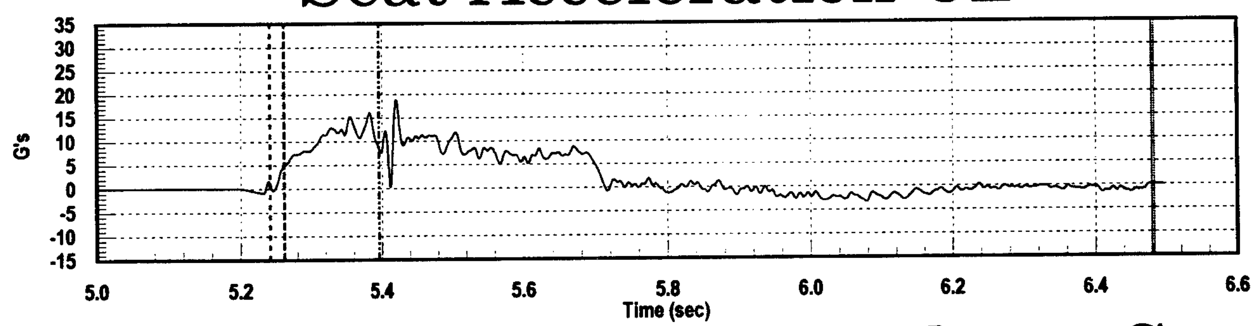
Seat Acceleration CX



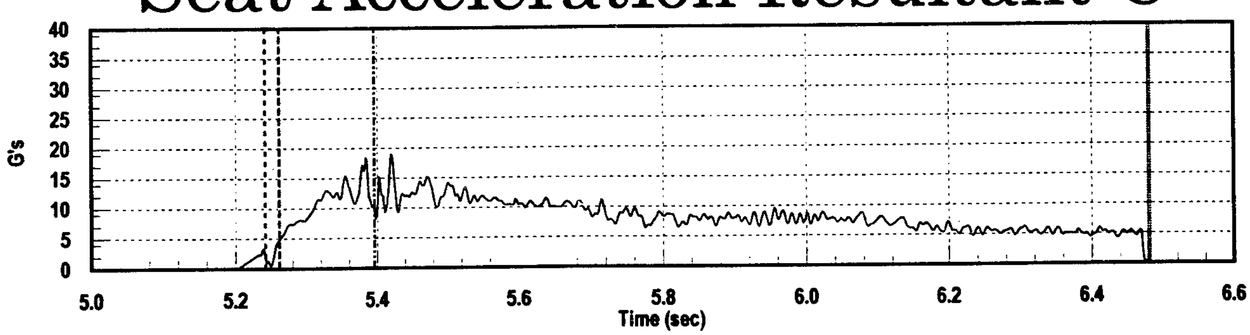
Seat Acceleration CY



Seat Acceleration CZ



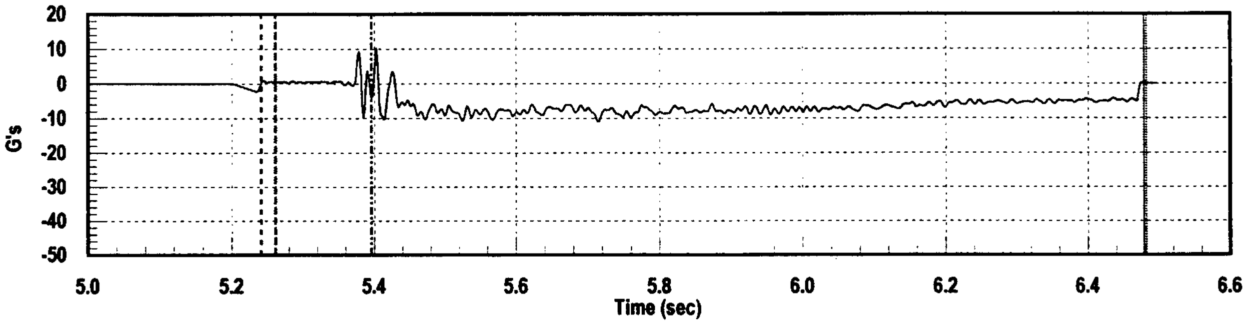
Seat Acceleration Resultant C



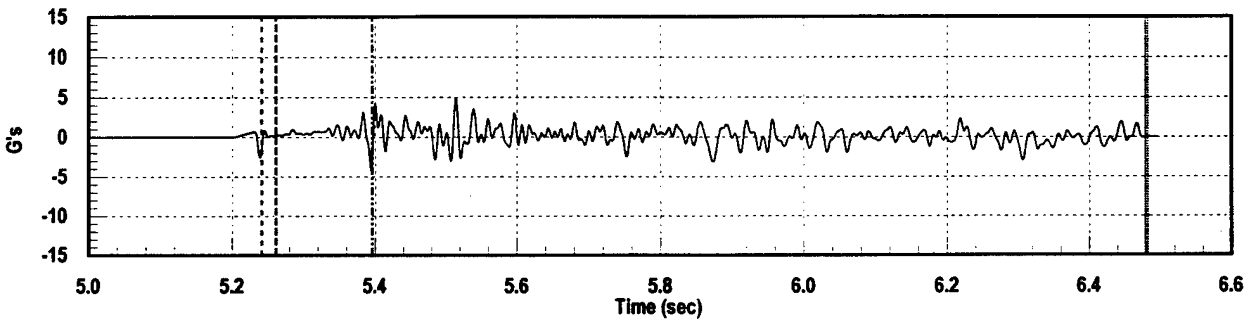
B-9

FL083301, 450 KEAS, 1,200 Ft

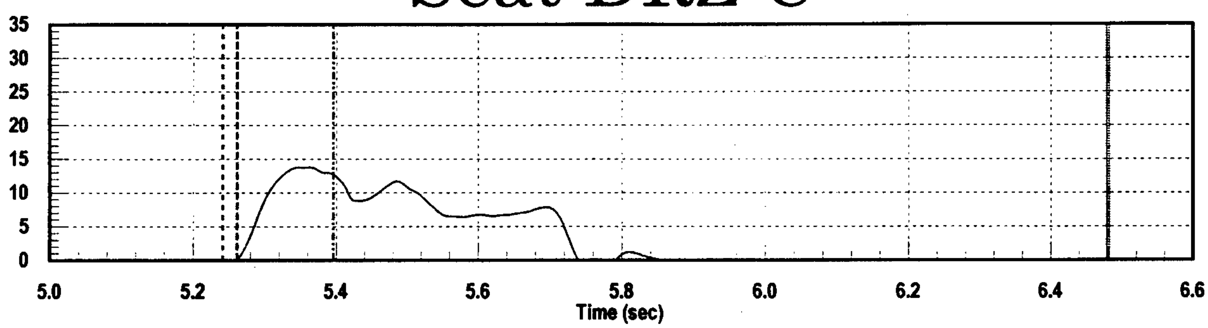
Seat Acceleration CX



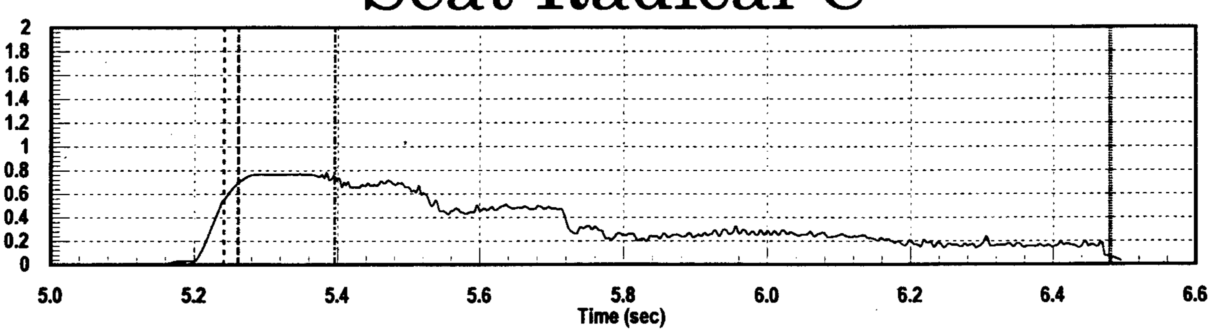
Seat Acceleration CY



Seat DRZ C



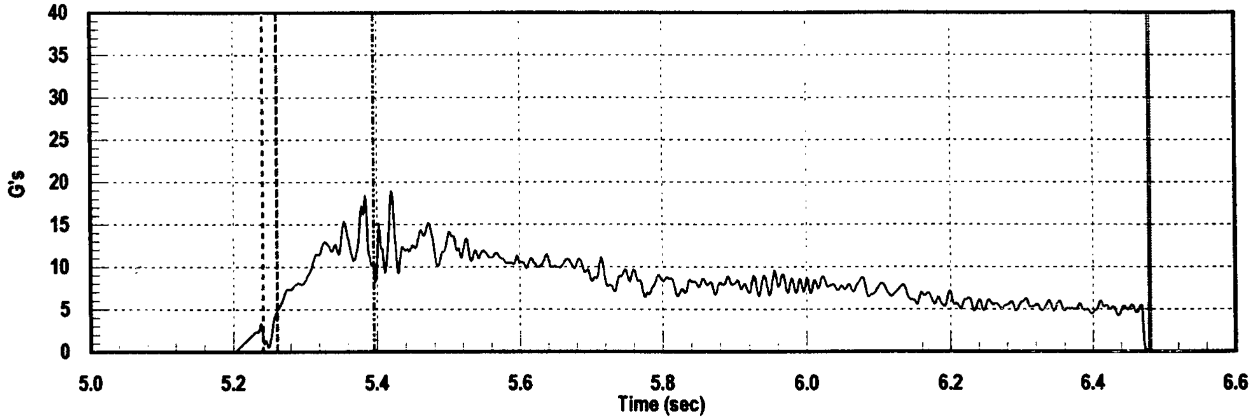
Seat Radical C



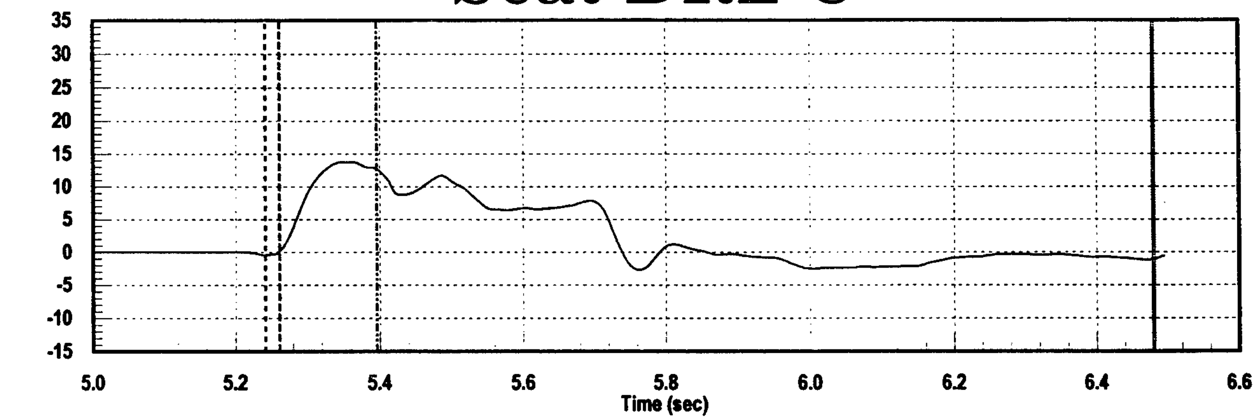
B-10

FL083301, 450 KEAS, 1,200 Ft

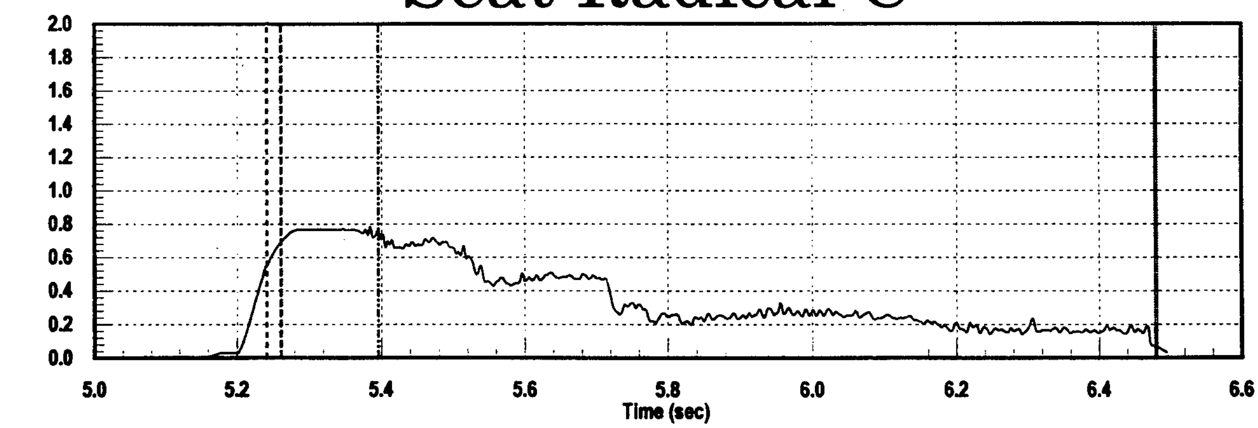
Seat Resultant C



Seat DRZ C



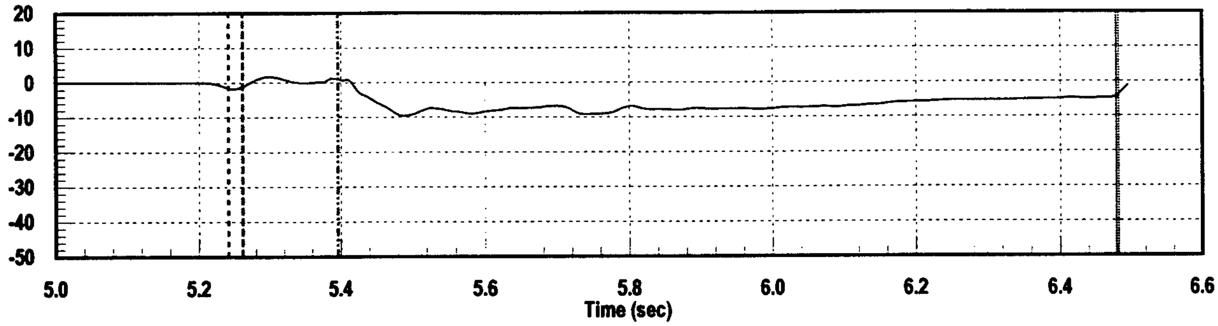
Seat Radical C



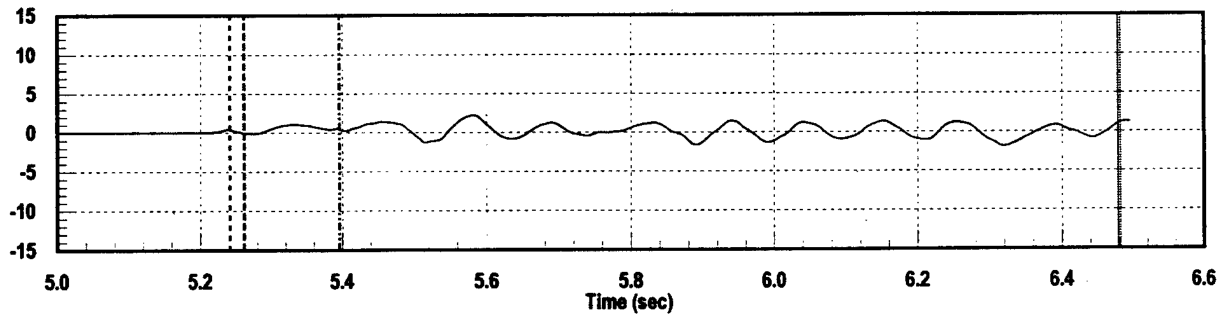
B-11

FL083301, 450 KEAS, 1,200 Ft

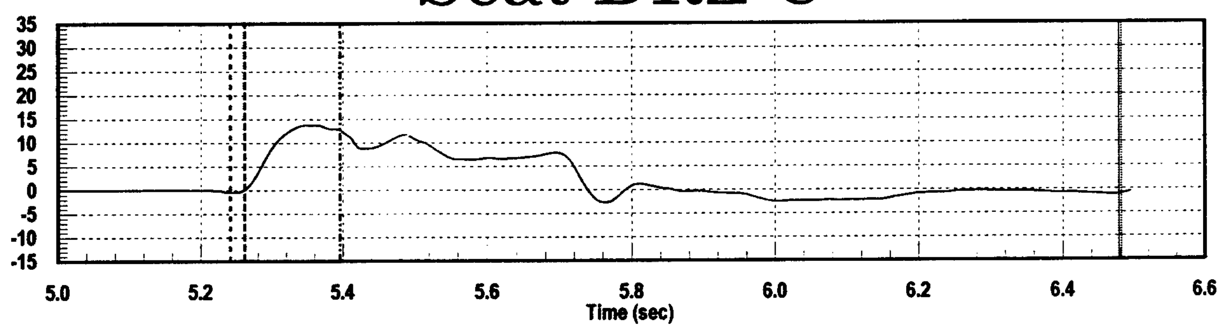
Seat DRX C



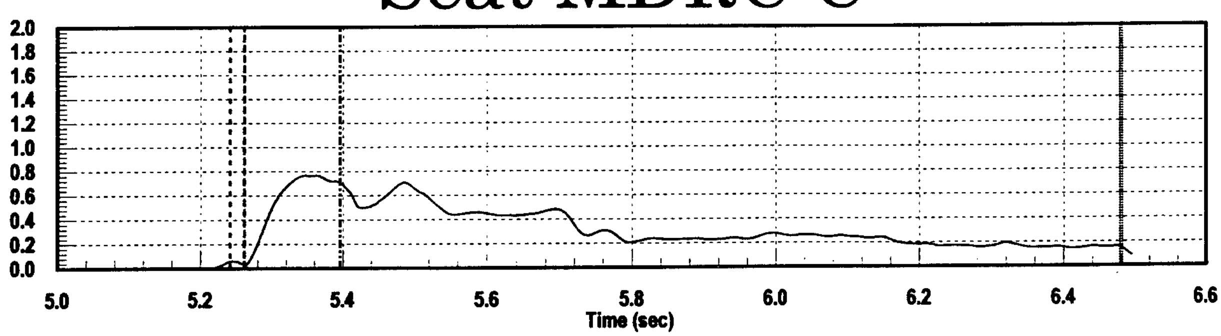
Seat DRY C



Seat DRZ C



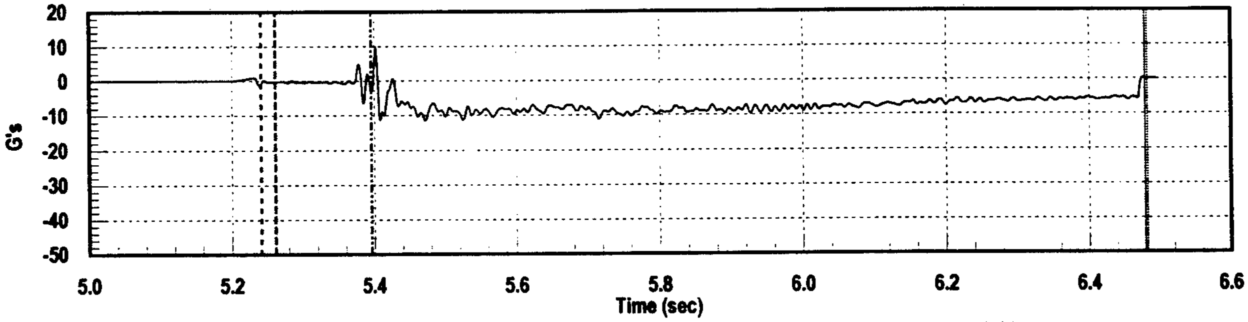
Seat MDRC C



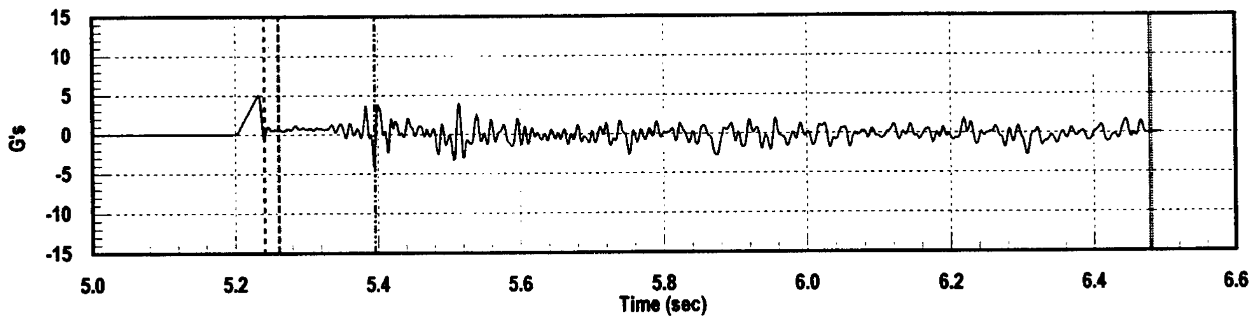
B-12

FL083301, 450 KEAS, 1,200 Ft

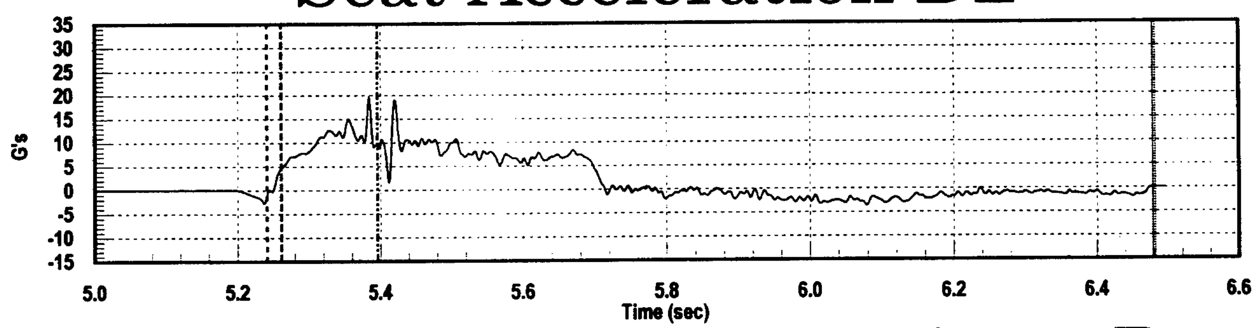
Seat Acceleration DX



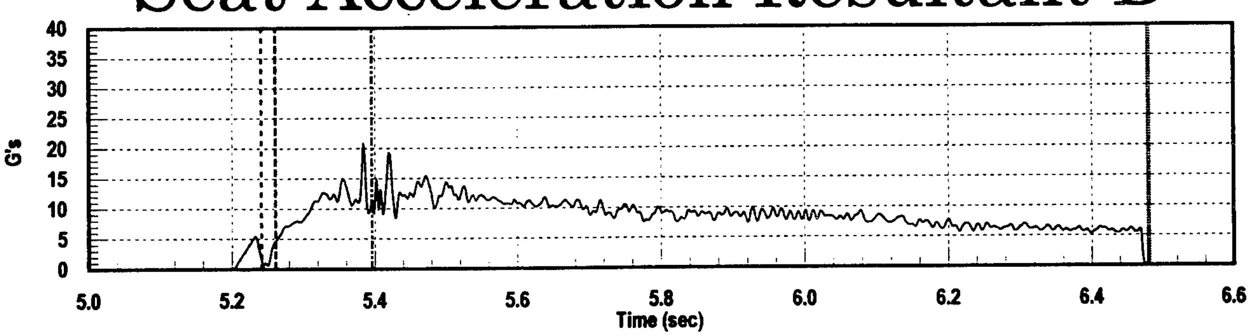
Seat Acceleration DY



Seat Acceleration DZ



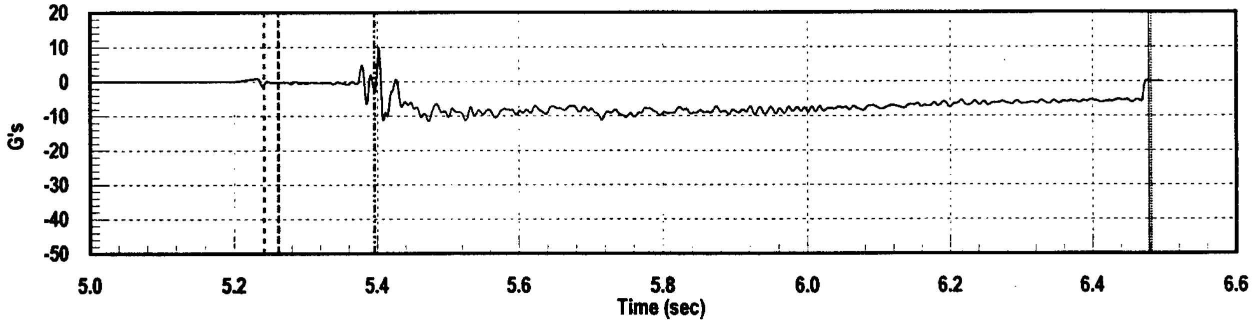
Seat Acceleration Resultant D



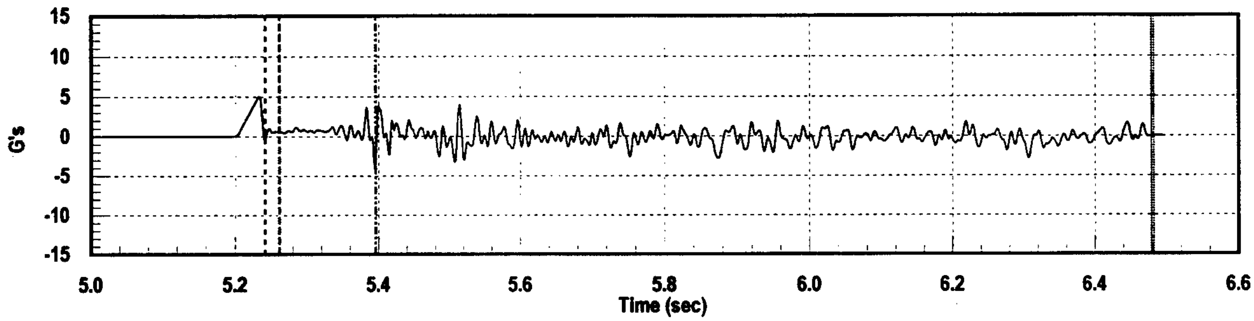
B-13

FL083301, 450 KEAS, 1,200 Ft

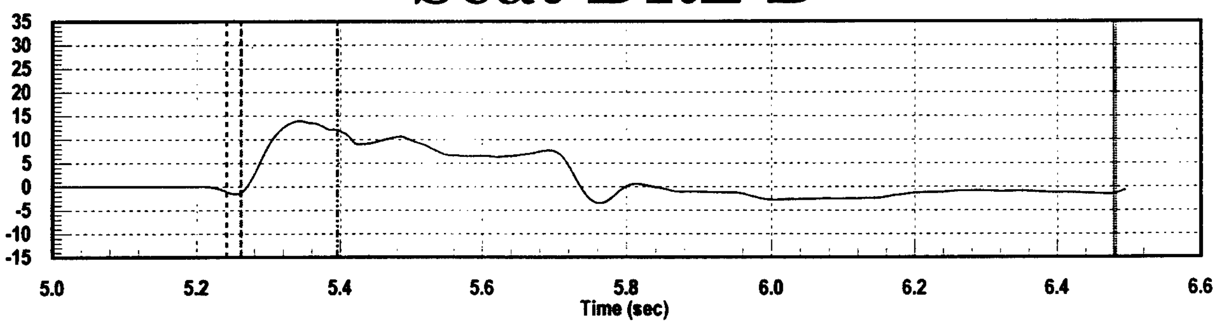
Seat Acceleration DX



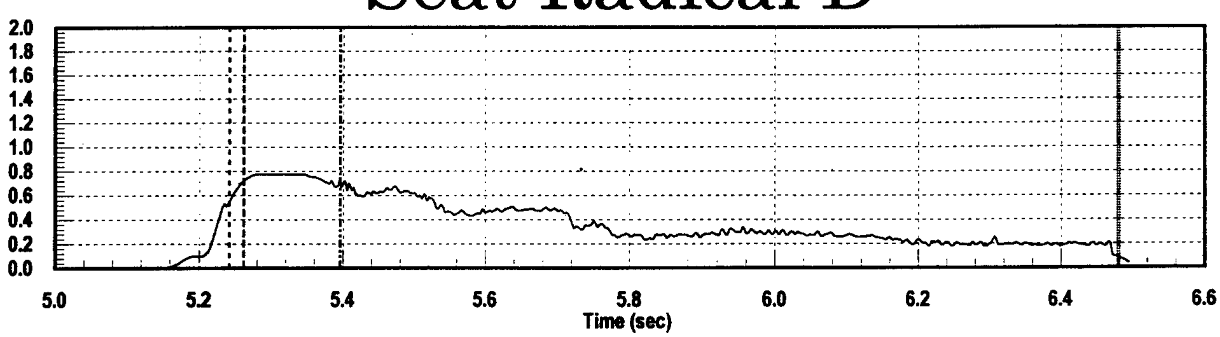
Seat Acceleration DY



Seat DRZ D



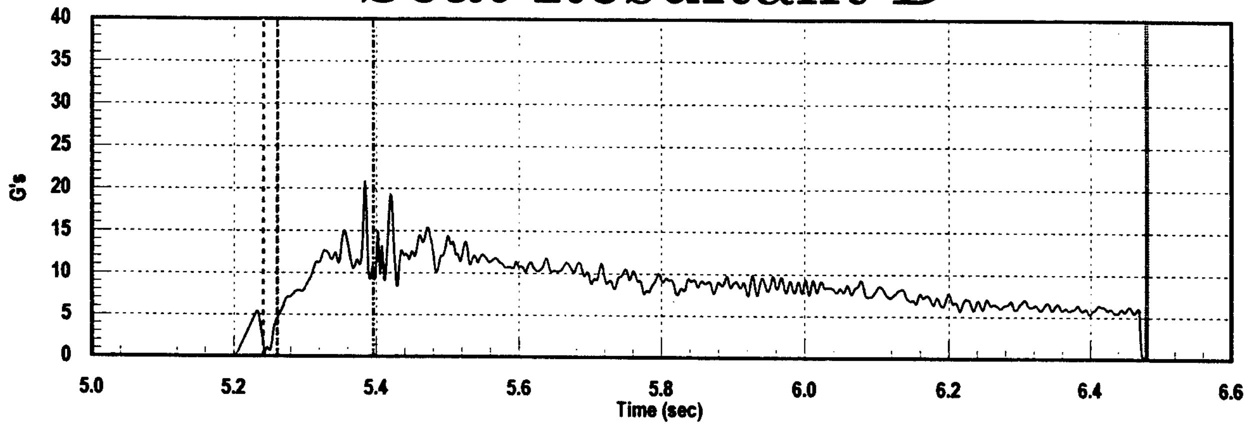
Seat Radical D



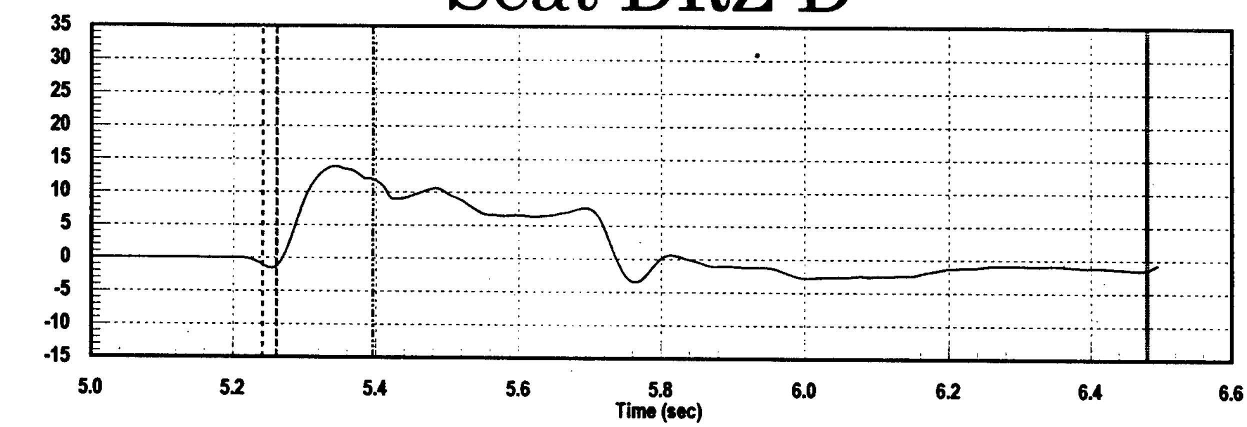
B-14

FL083301, 450 KEAS, 1,200 Ft

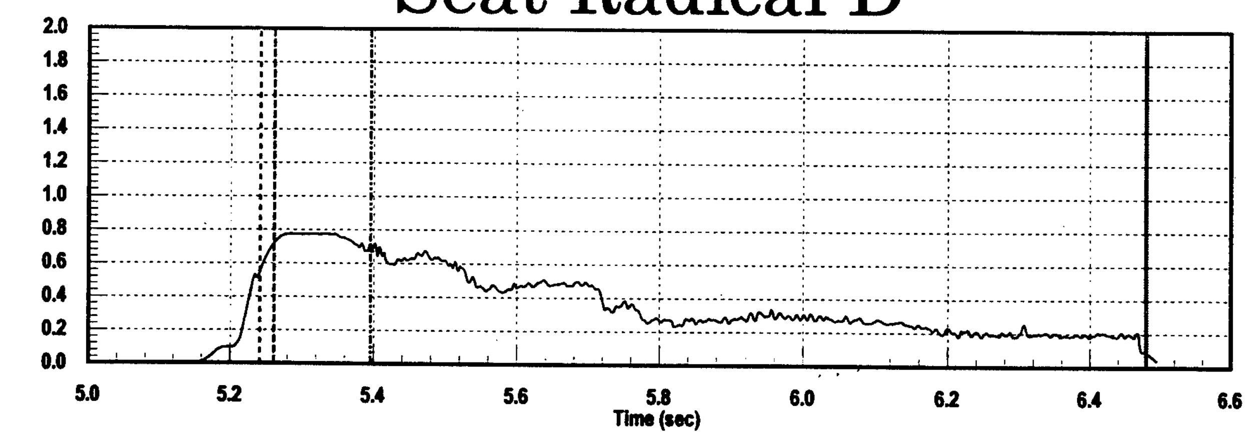
Seat Resultant D



Seat DRZ D



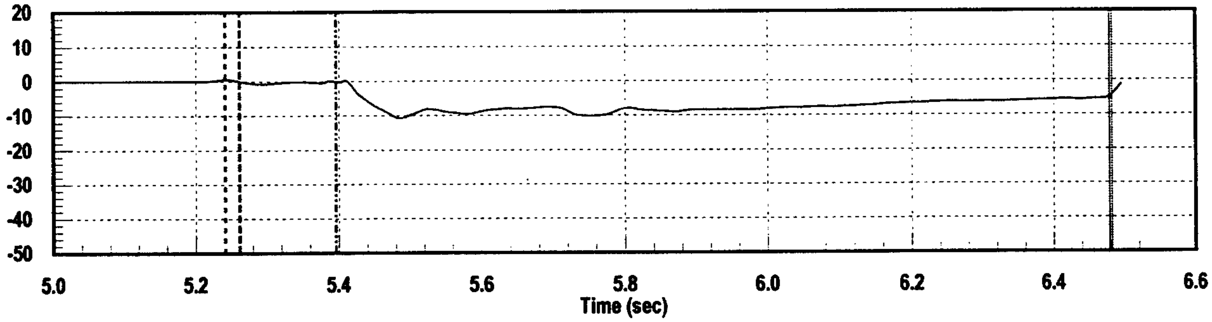
Seat Radical D



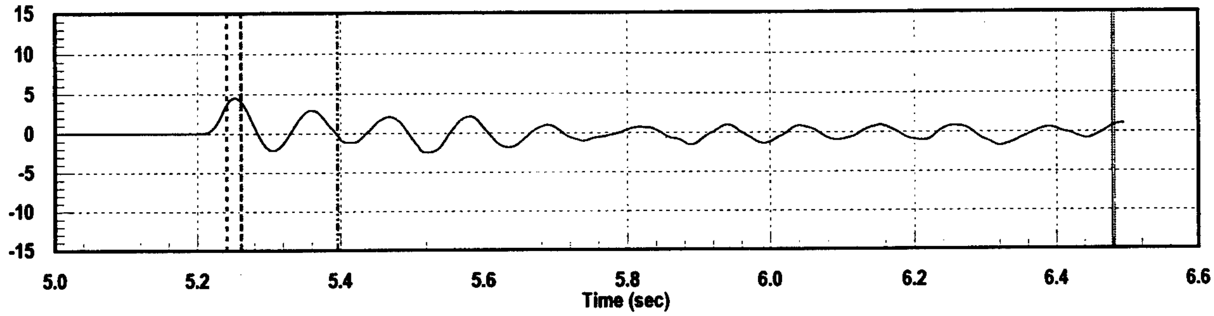
B-15

FL083301, 450 KEAS, 1,200 Ft

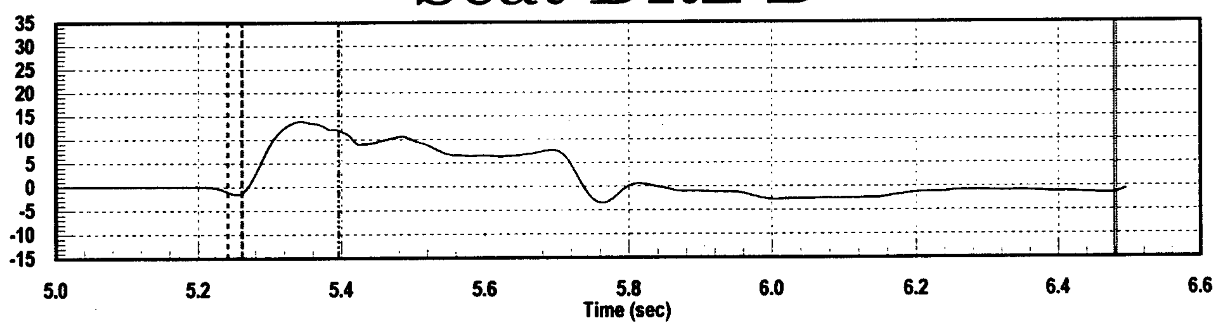
Seat DRX D



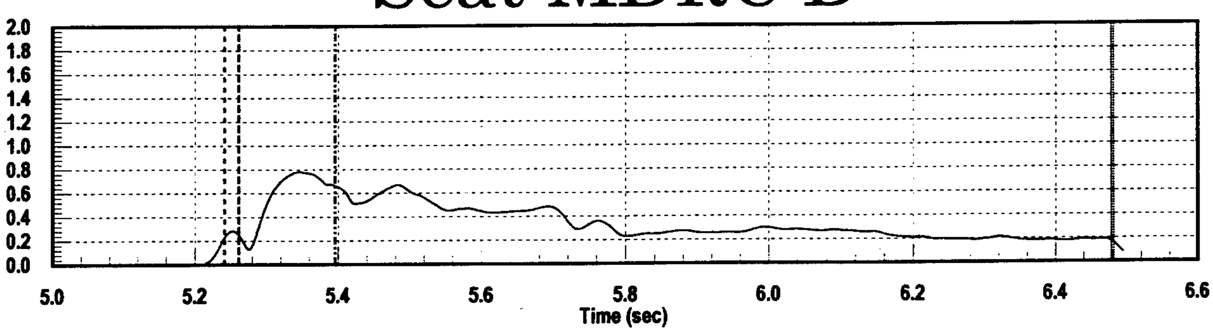
Seat DRY D



Seat DRZ D



Seat MDRC D



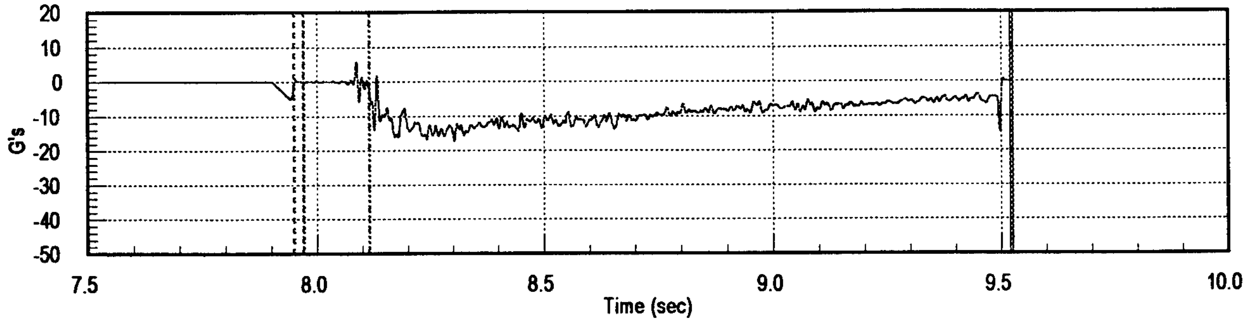
B-16

FL105001, 545 KEAS, 1,800 Ft Dynamic Response Analysis

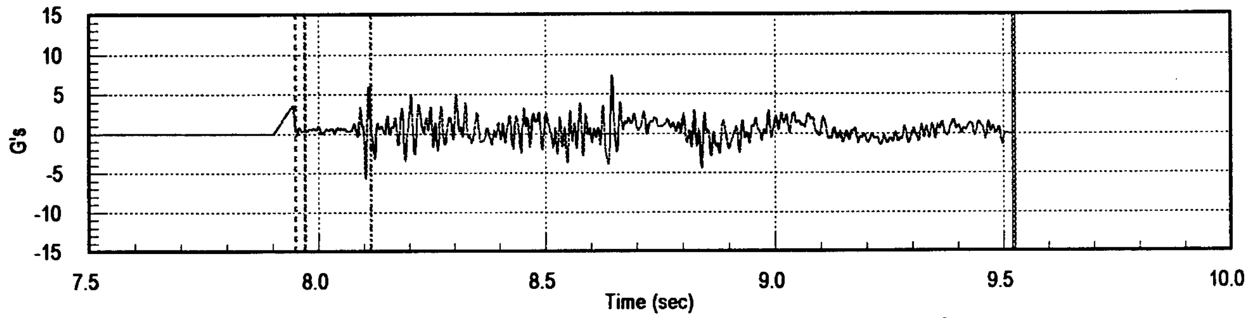
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL105001, 545 KEAS, 1,800 Ft

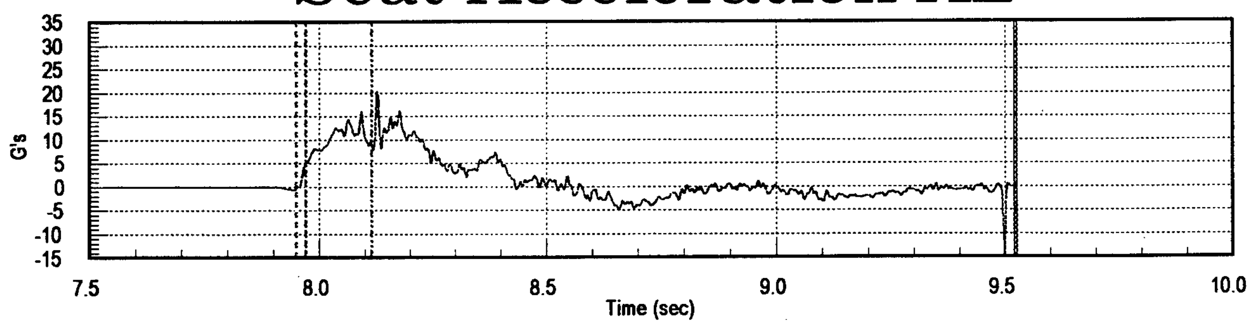
Seat Acceleration AX



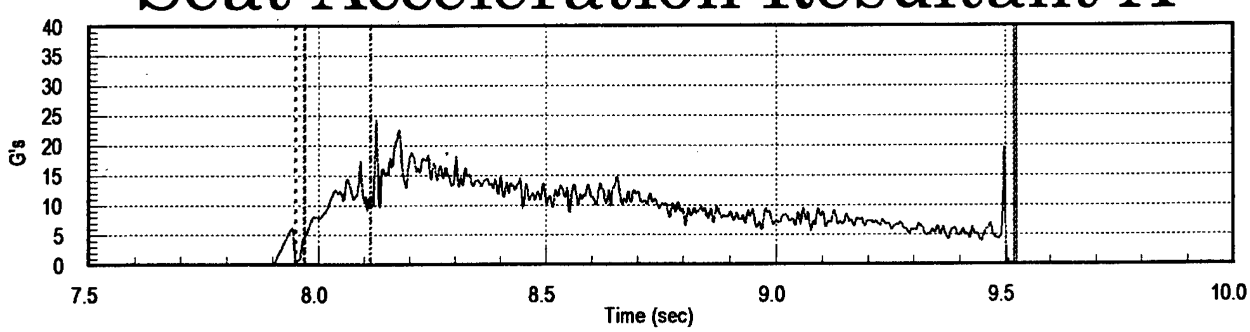
Seat Acceleration AY



Seat Acceleration AZ



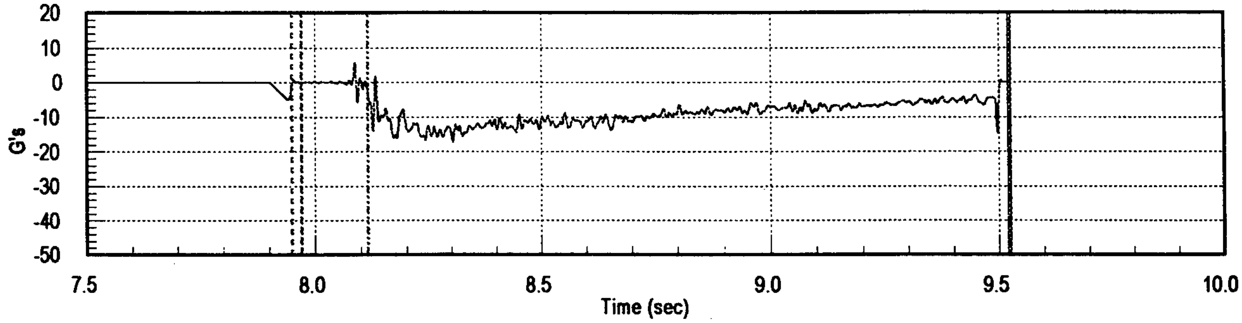
Seat Acceleration Resultant A



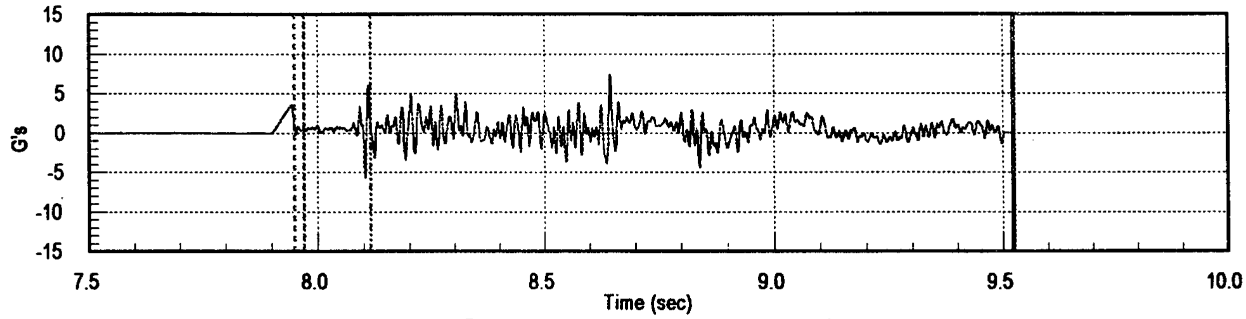
B-1

FL105001, 545 KEAS, 1,800 Ft

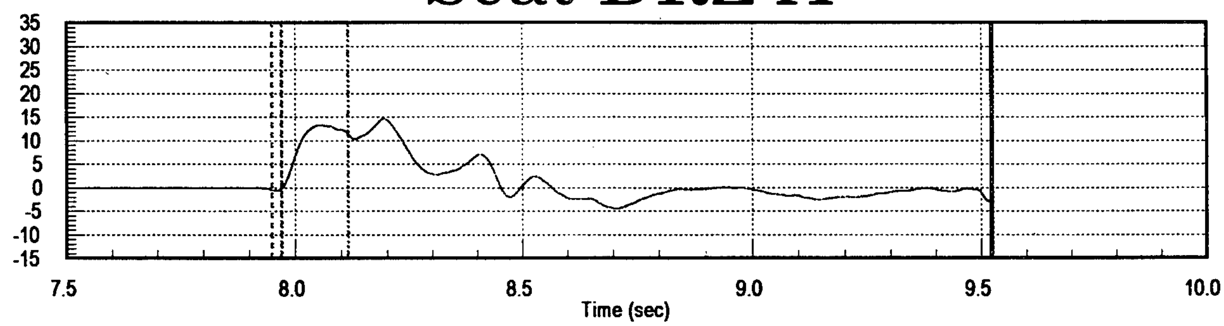
Seat Acceleration AX



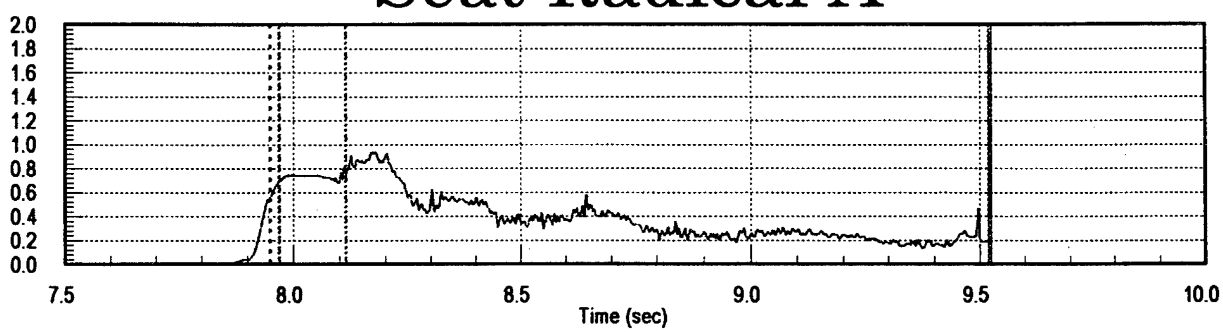
Seat Acceleration AY



Seat DRZ A



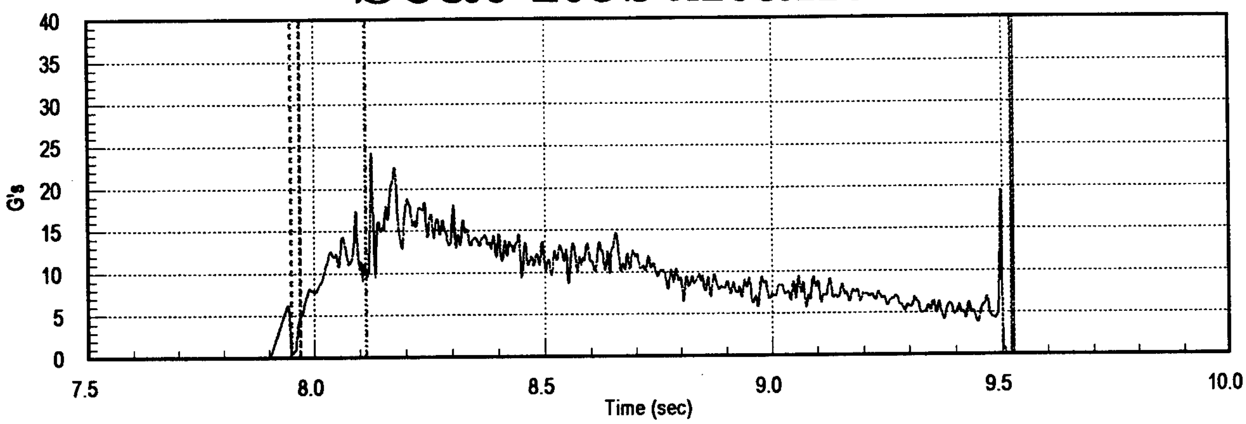
Seat Radical A



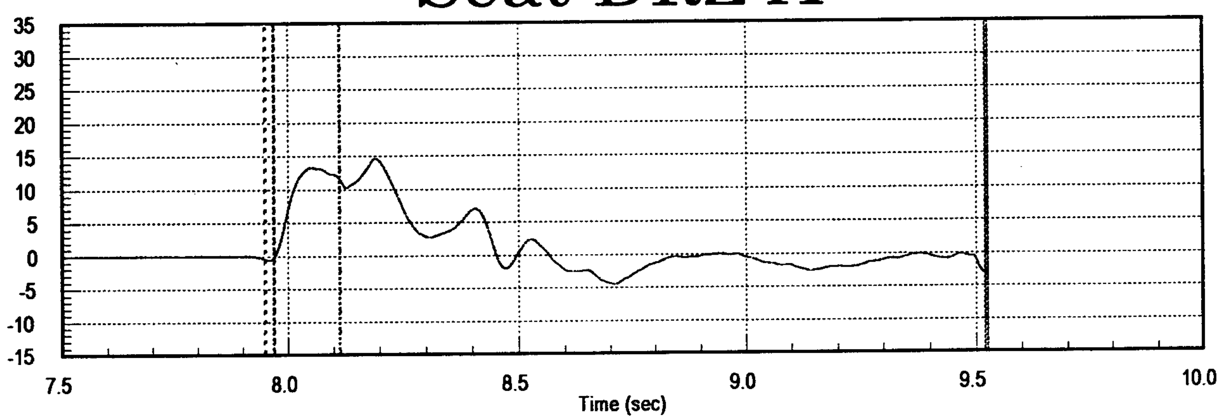
B-2

FL105001, 545 KEAS, 1,800 Ft

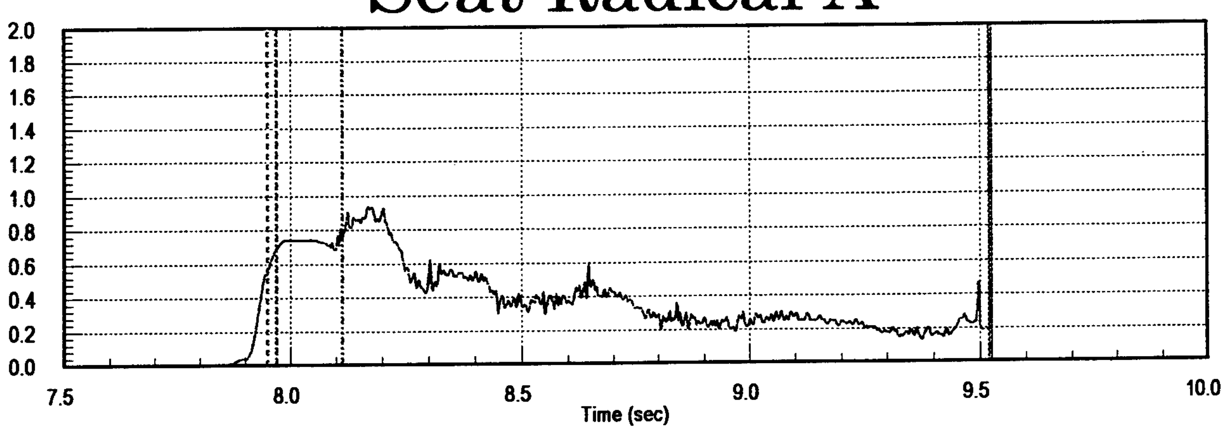
Seat Resultant A



Seat DRZ A



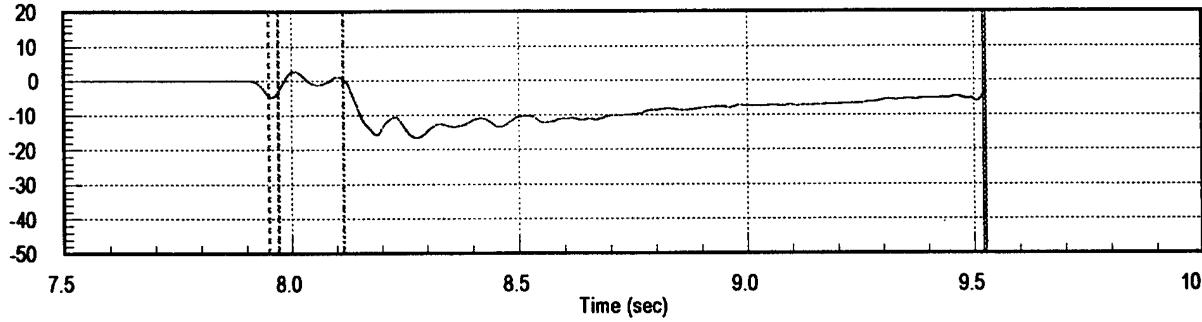
Seat Radical A



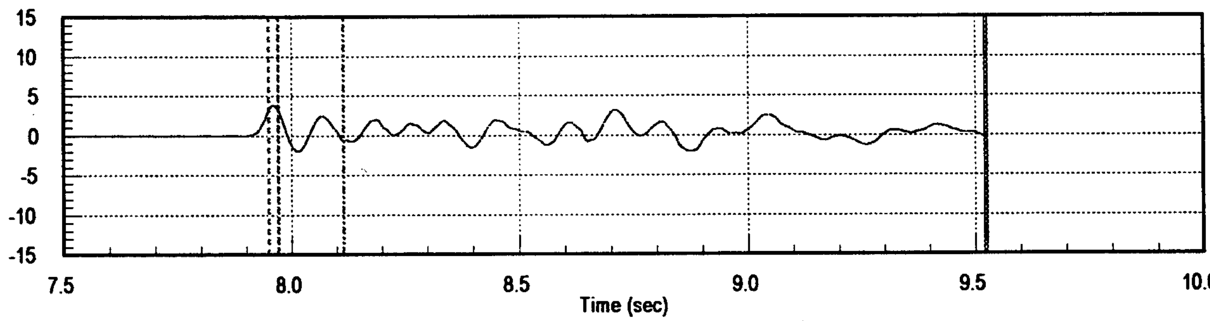
B-3

FL105001, 545 KEAS, 1,800 Ft

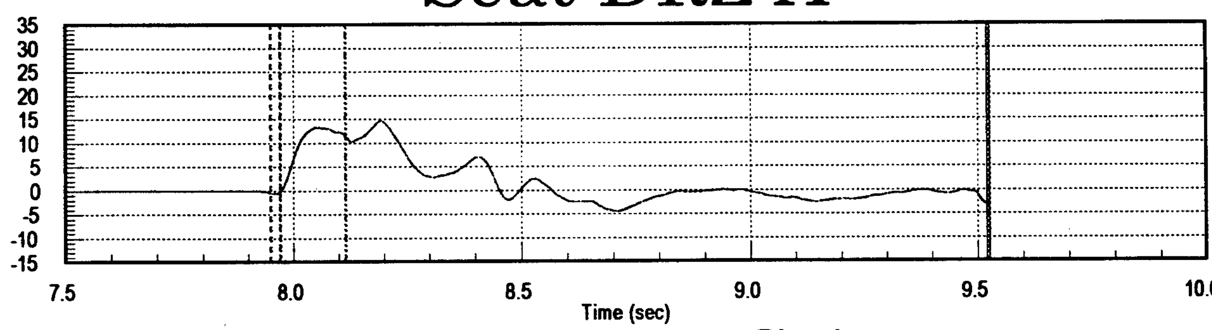
Seat DRX A



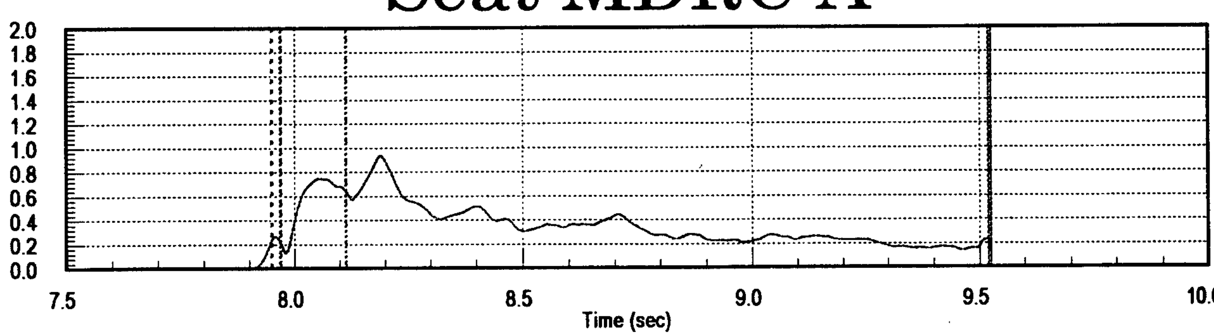
Seat DRY A



Seat DRZ A



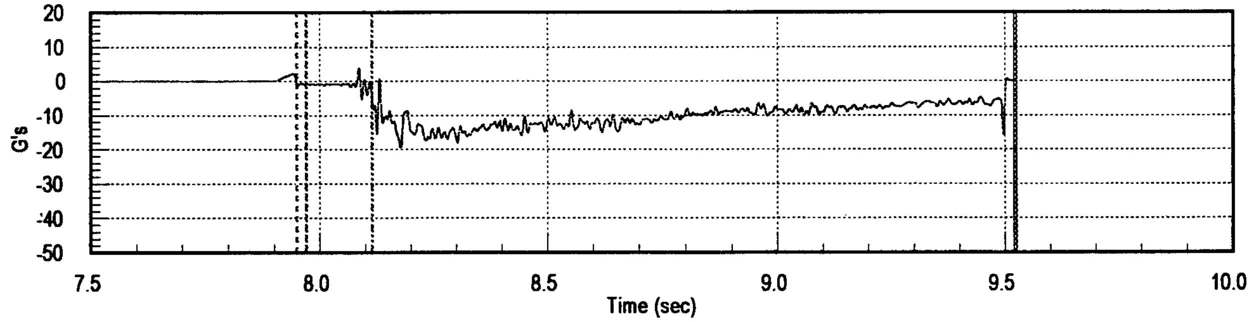
Seat MDRC A



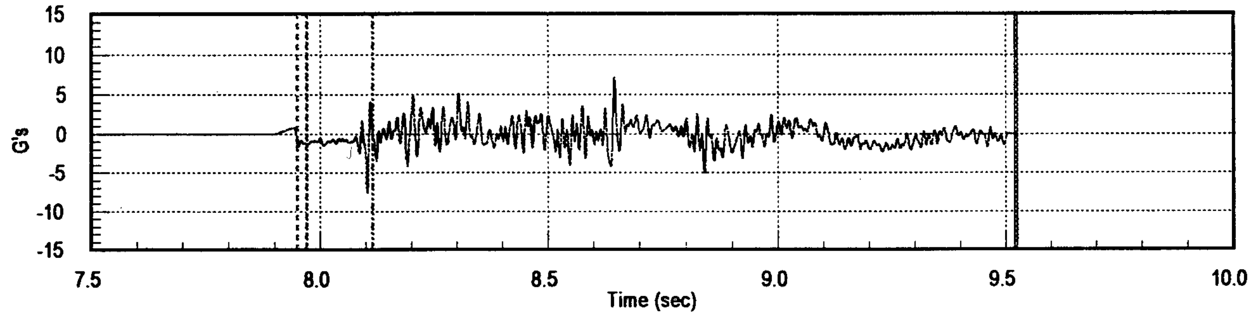
B-4

FL105001, 545 KEAS, 1,800 Ft

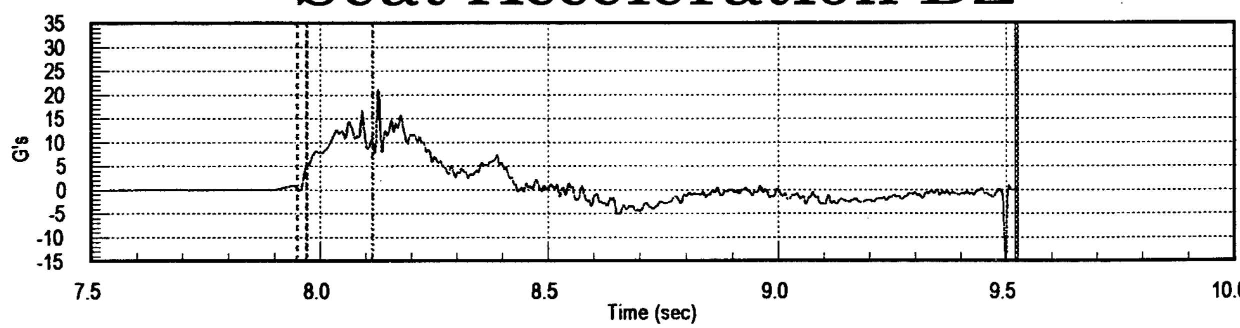
Seat Acceleration BX



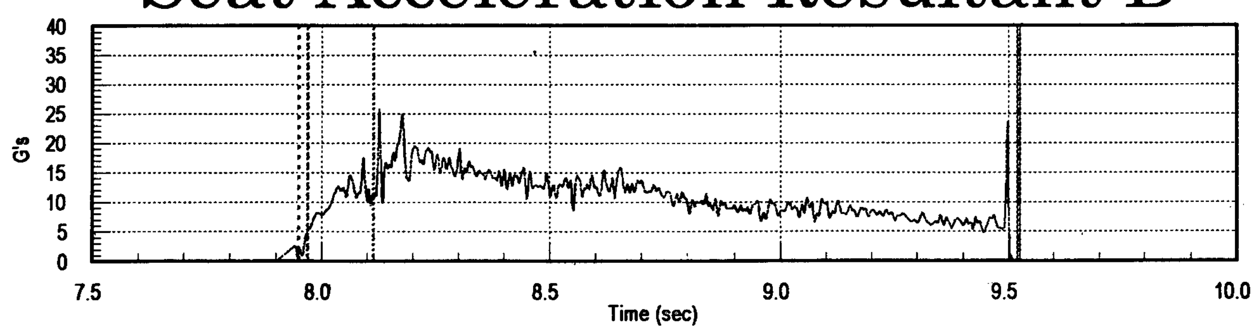
Seat Acceleration BY



Seat Acceleration BZ



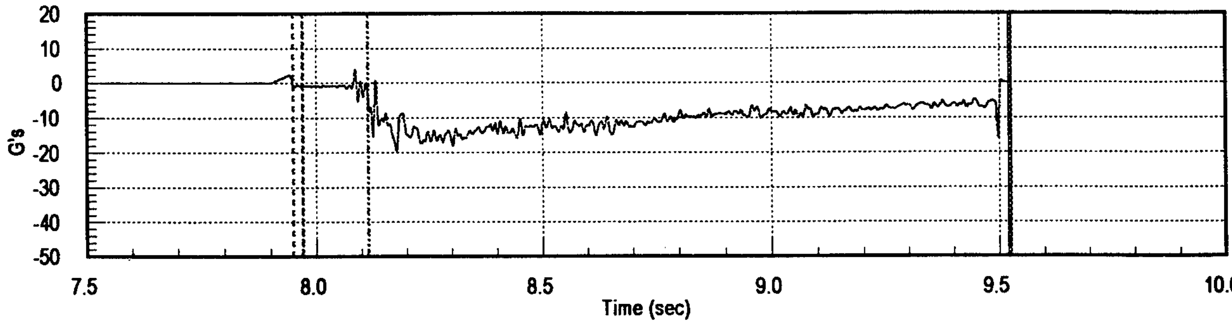
Seat Acceleration Resultant B



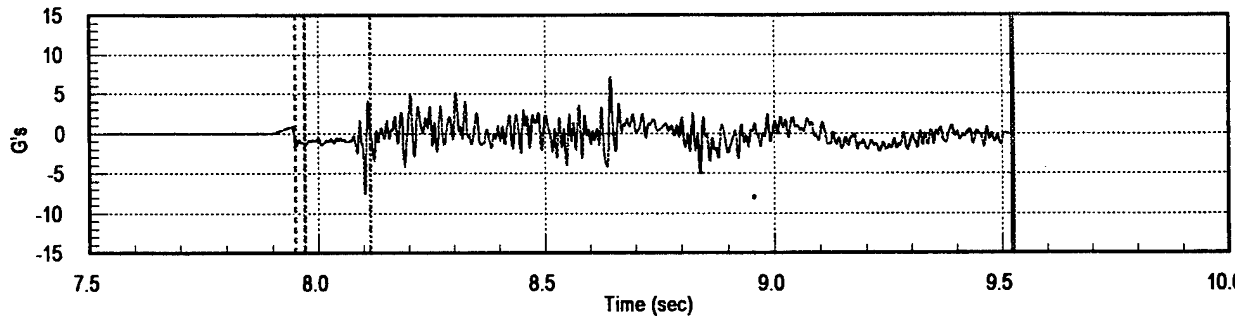
B-5

FL105001, 545 KEAS, 1,800 Ft

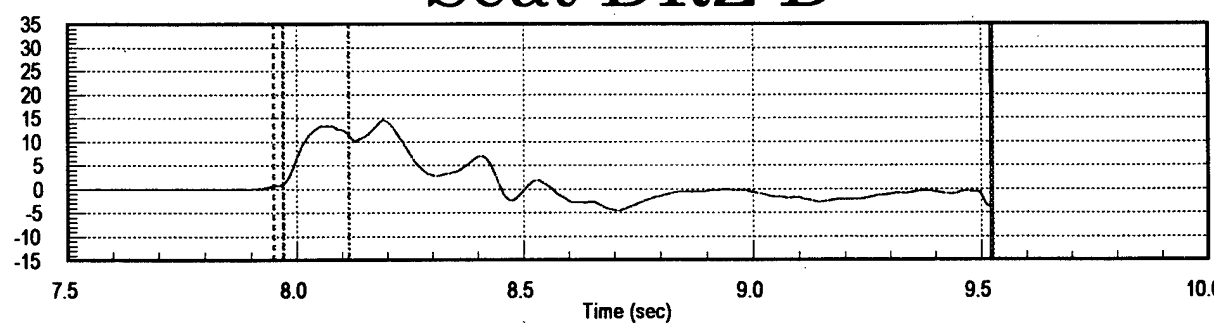
Seat Acceleration BX



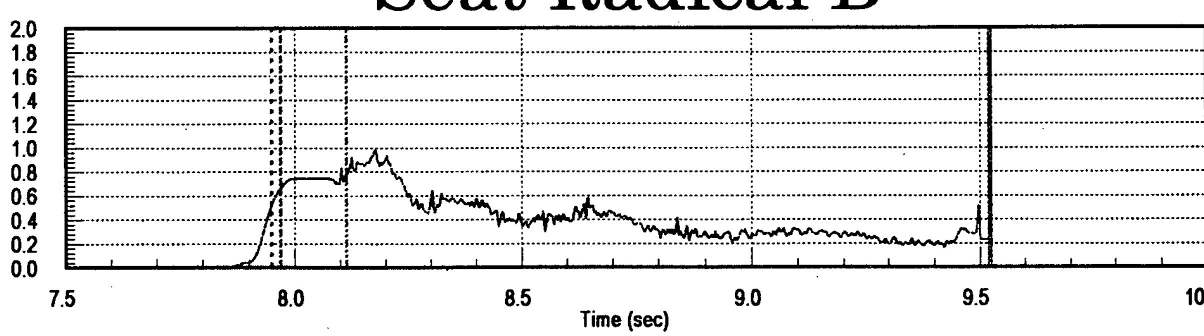
Seat Acceleration BY



Seat DRZ B

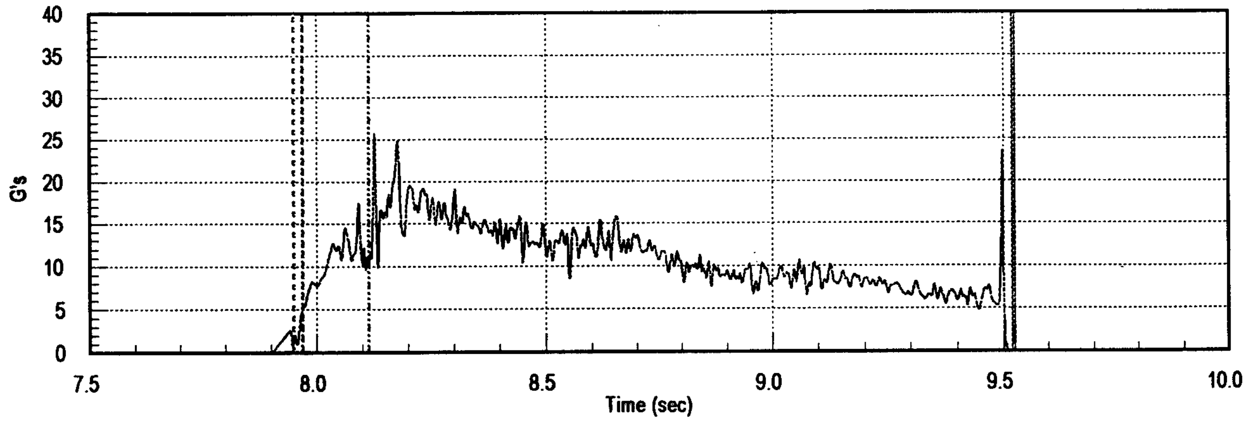


Seat Radical B

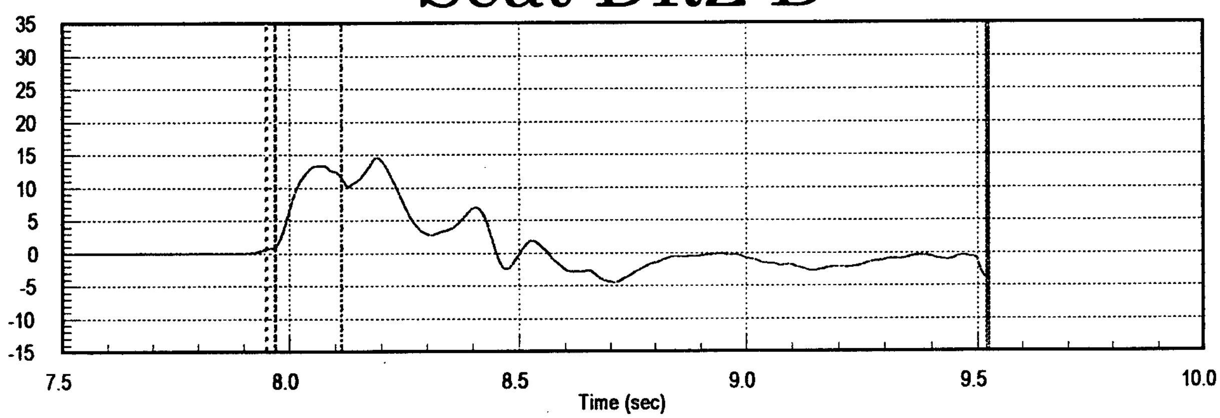


FL105001, 545 KEAS, 1,800 Ft

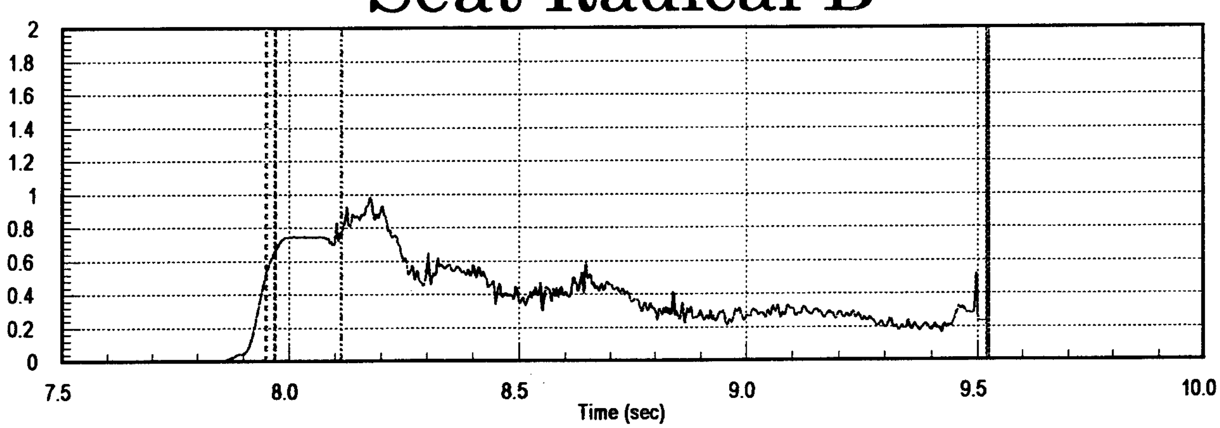
Seat Resultant B



Seat DRZ B



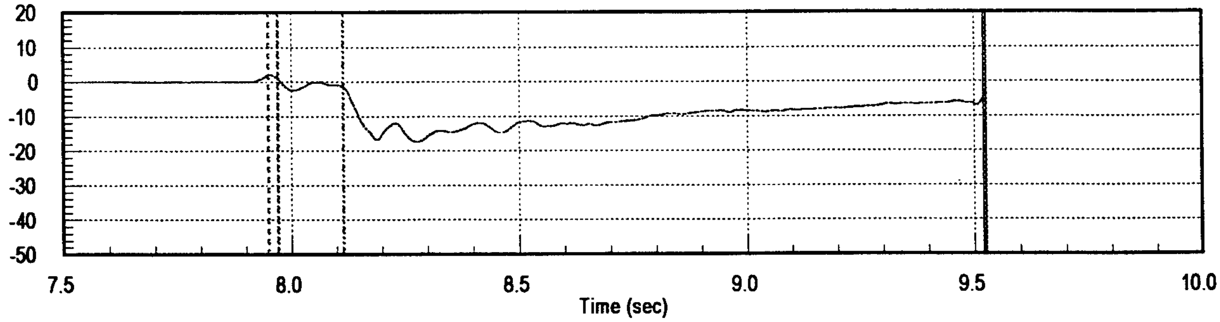
Seat Radical B



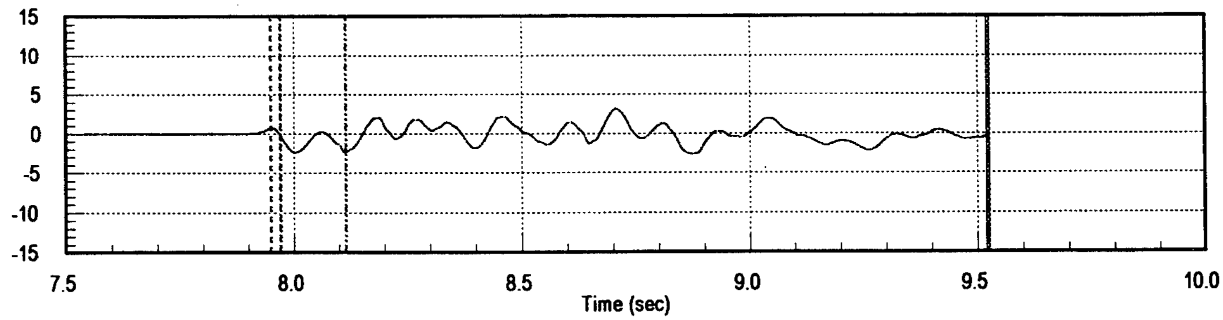
B-7

FL105001, 545 KEAS, 1,800 Ft

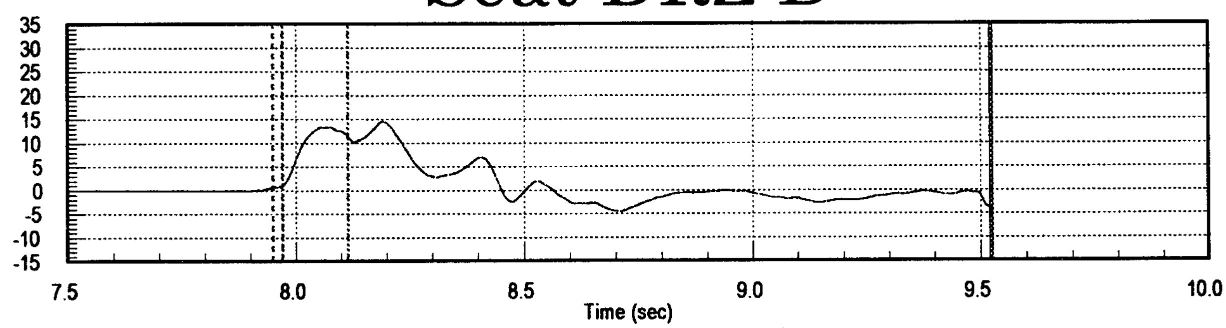
Seat DRX B



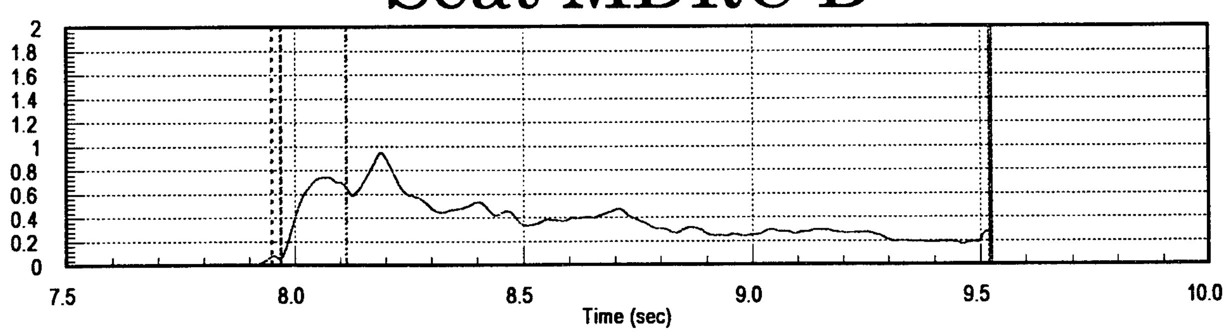
Seat DRY B



Seat DRZ B



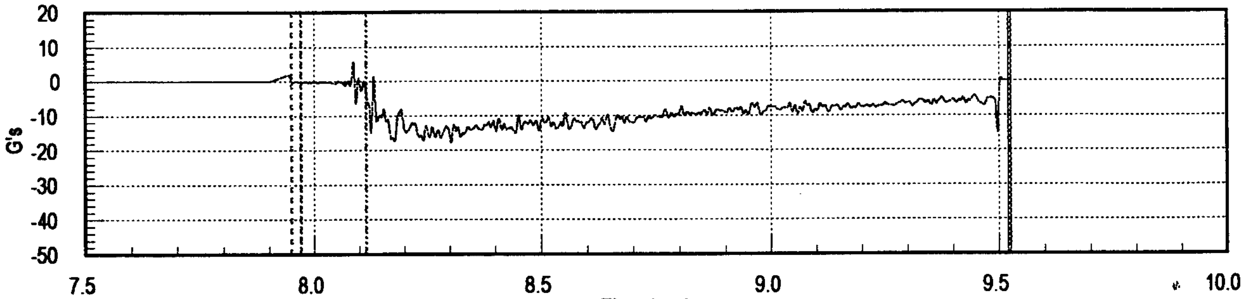
Seat MDRC B



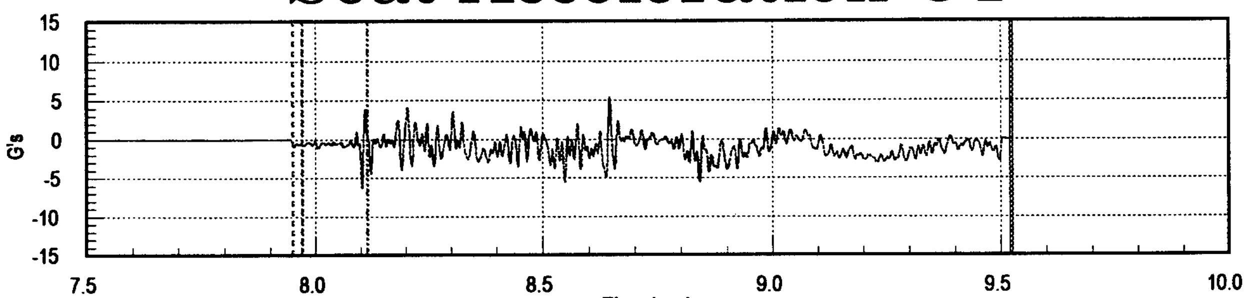
B-8

FL105001, 545 KEAS, 1,800 Ft

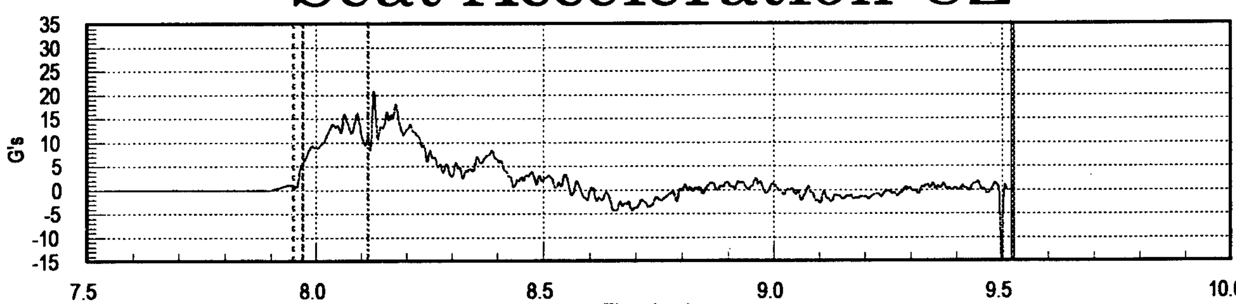
Seat Acceleration CX



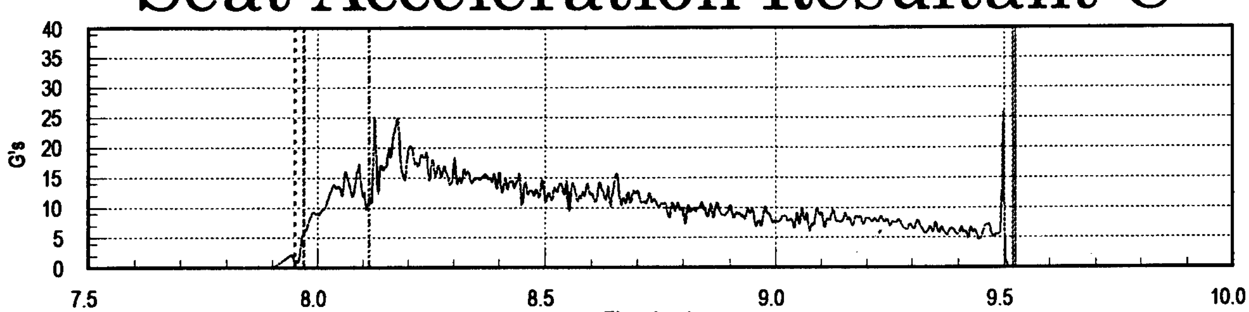
Seat Acceleration CY



Seat Acceleration CZ



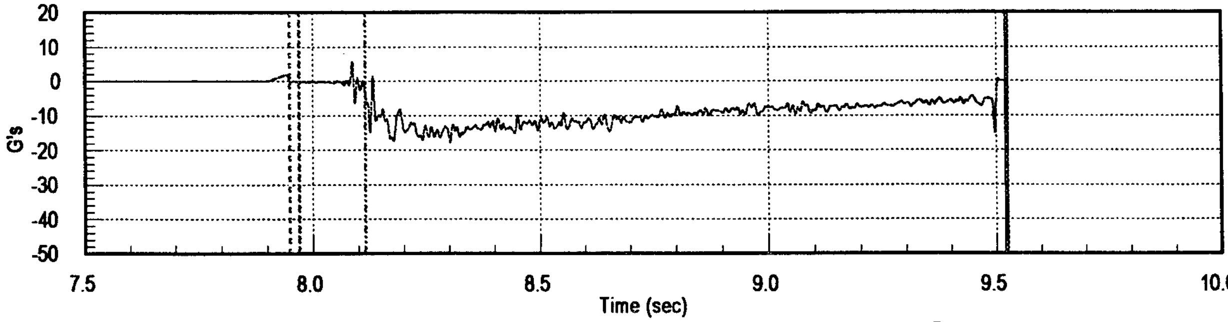
Seat Acceleration Resultant C



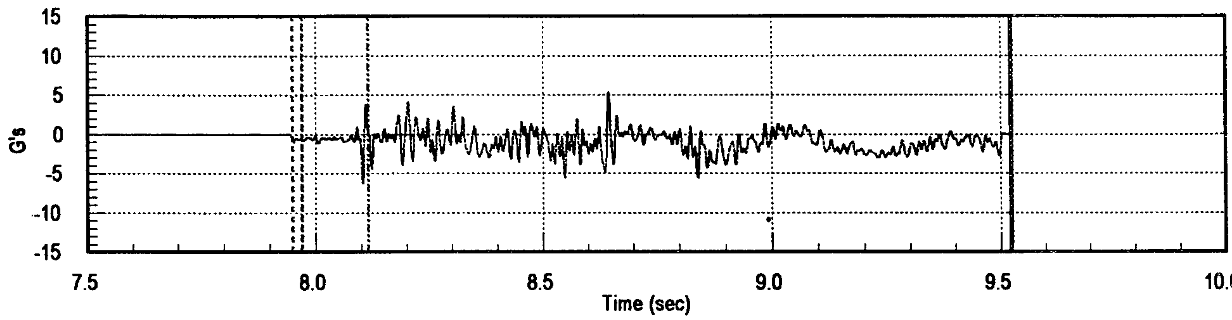
B-9

FL105001, 545 KEAS, 1,800 Ft

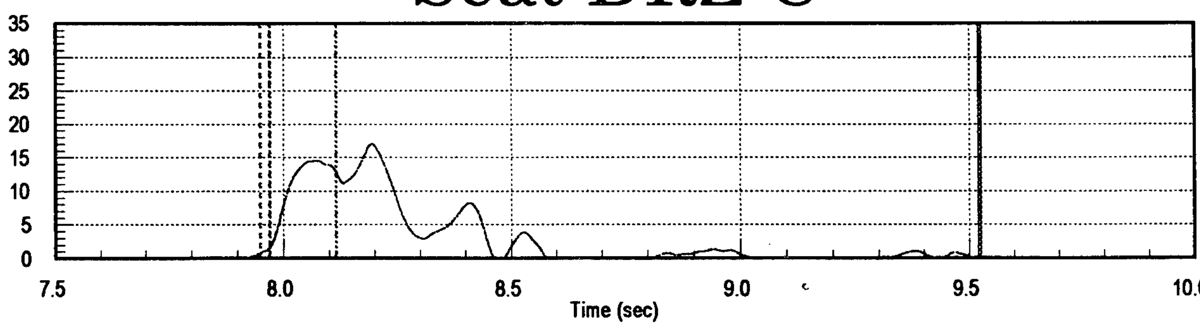
Seat Acceleration CX



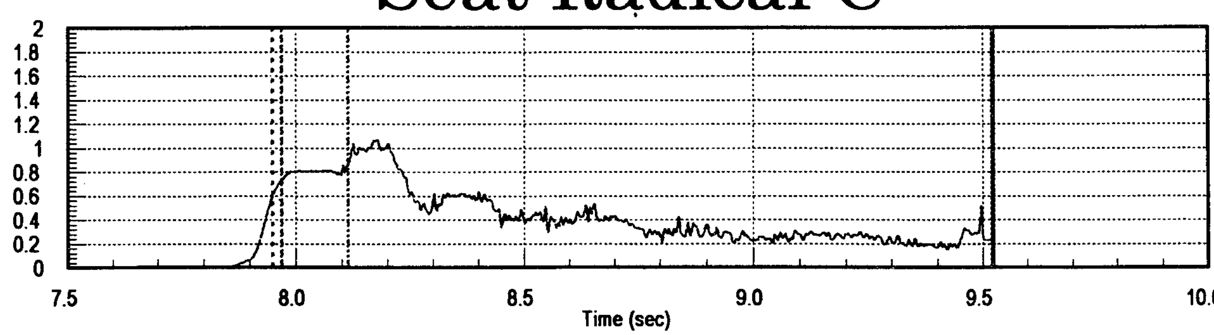
Seat Acceleration CY



Seat DRZ C



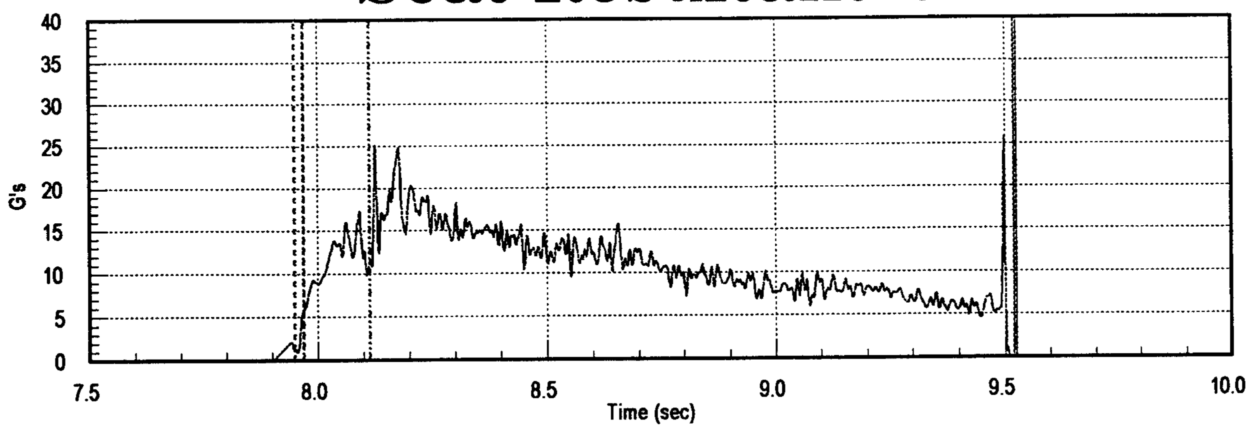
Seat Radical C



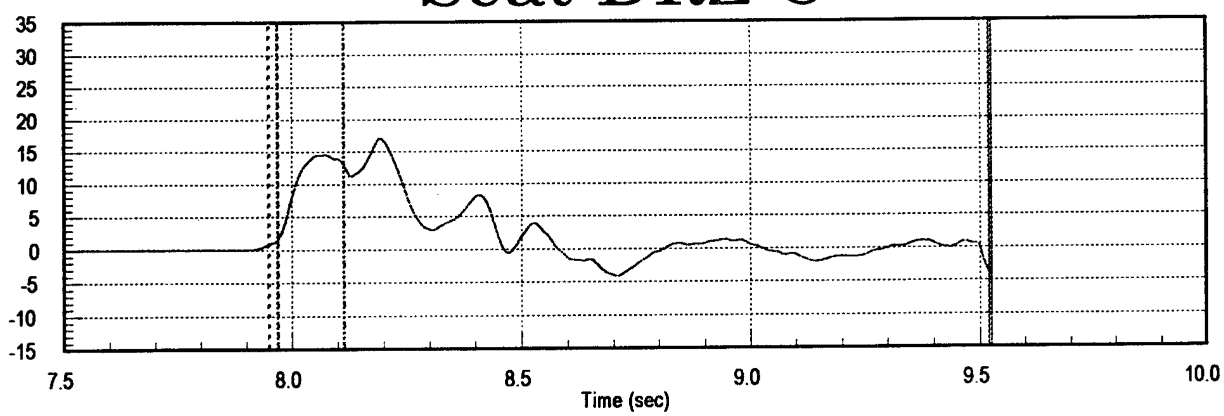
B-10

FL105001, 545 KEAS, 1,800 Ft

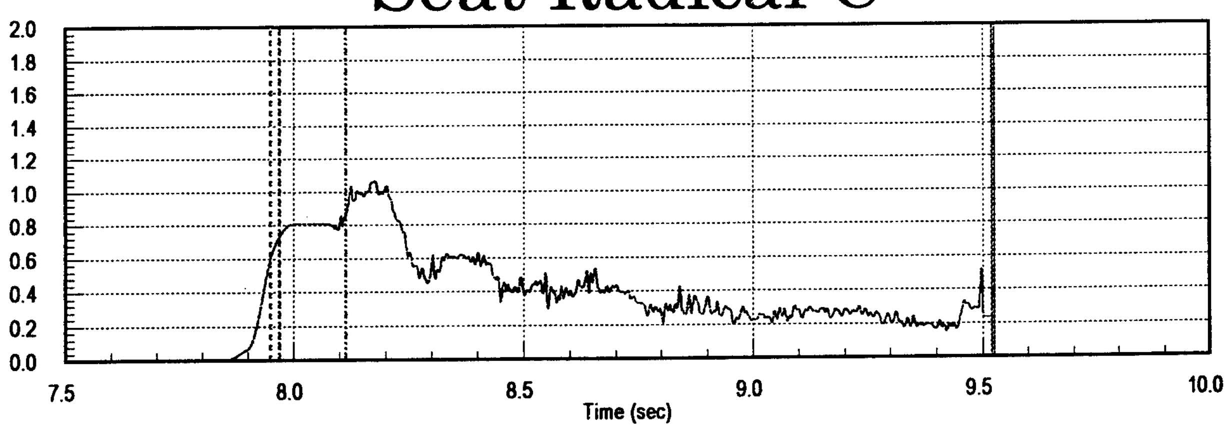
Seat Resultant C



Seat DRZ C



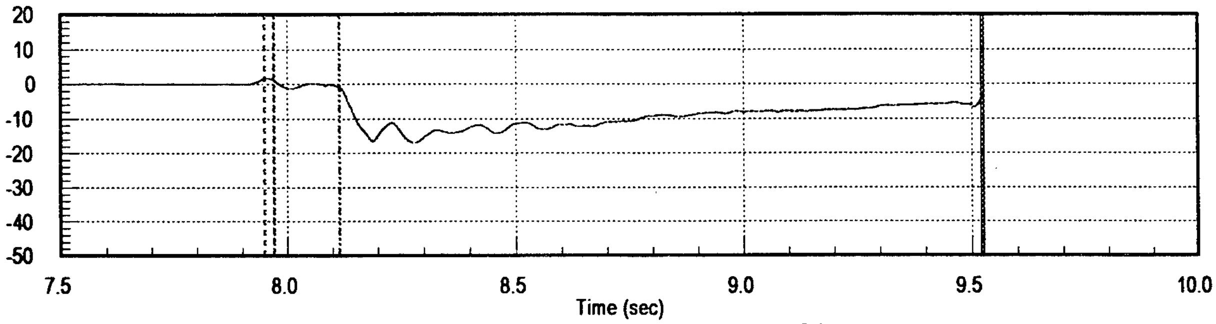
Seat Radical C



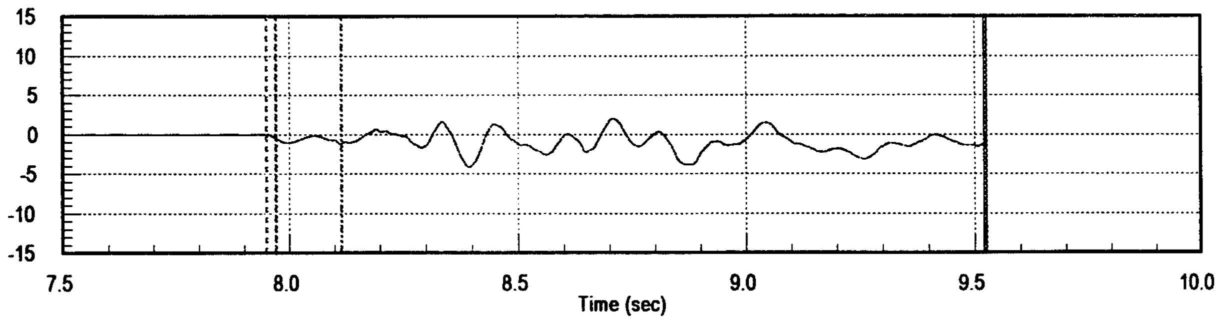
B-11

FL105001, 545 KEAS, 1,800 Ft

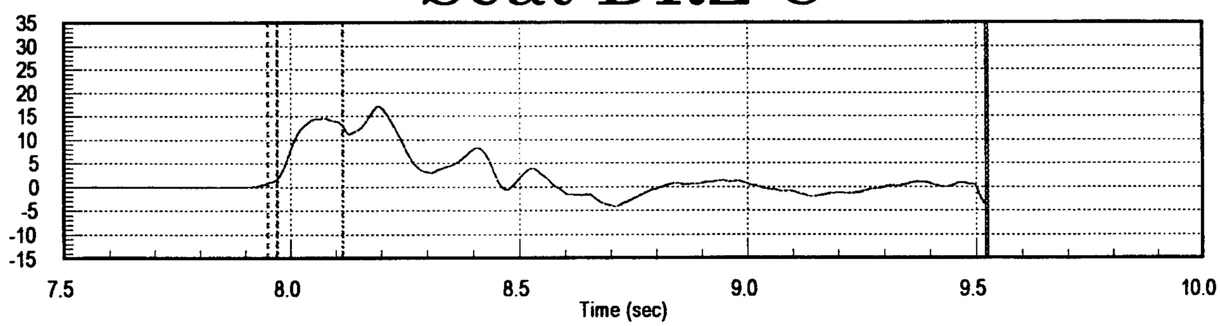
Seat DRX C



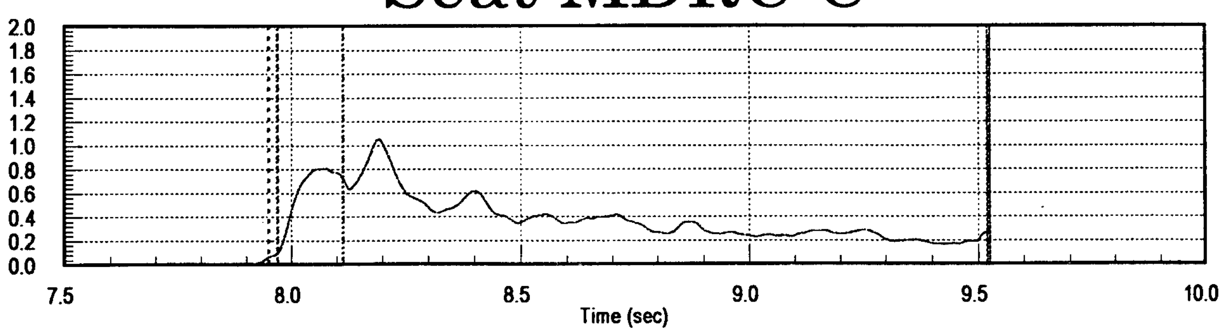
Seat DRY C



Seat DRZ C



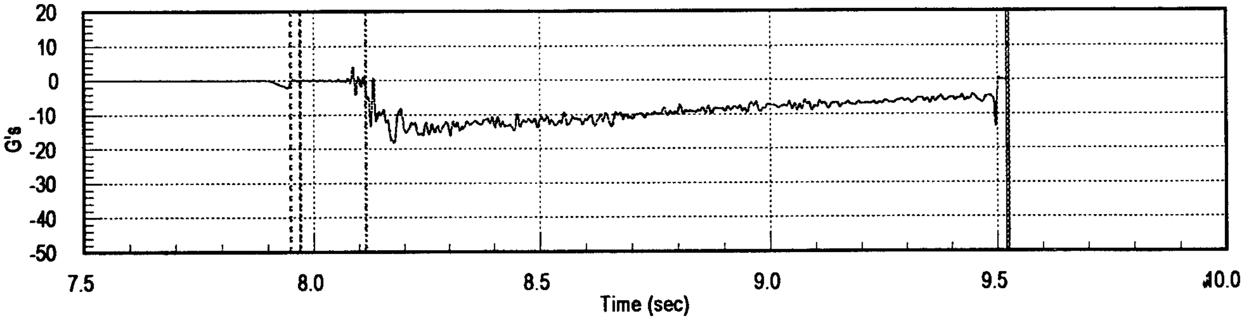
Seat MDRC C



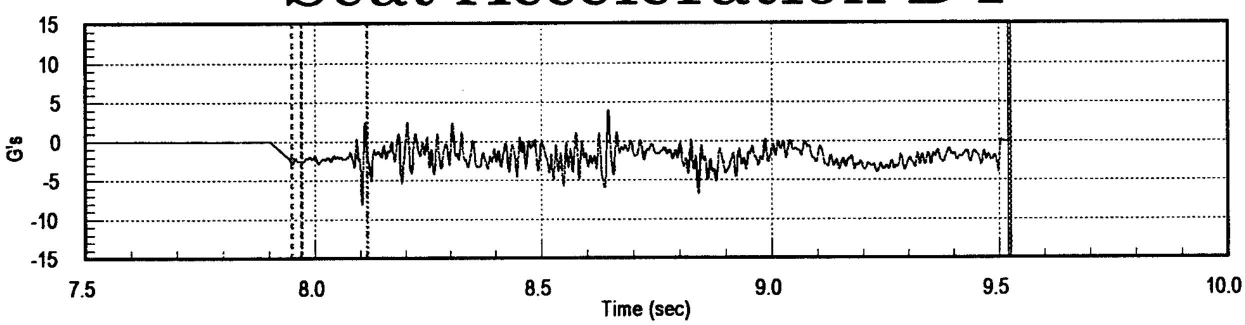
B-12

FL105001, 545 KEAS, 1,800 Ft

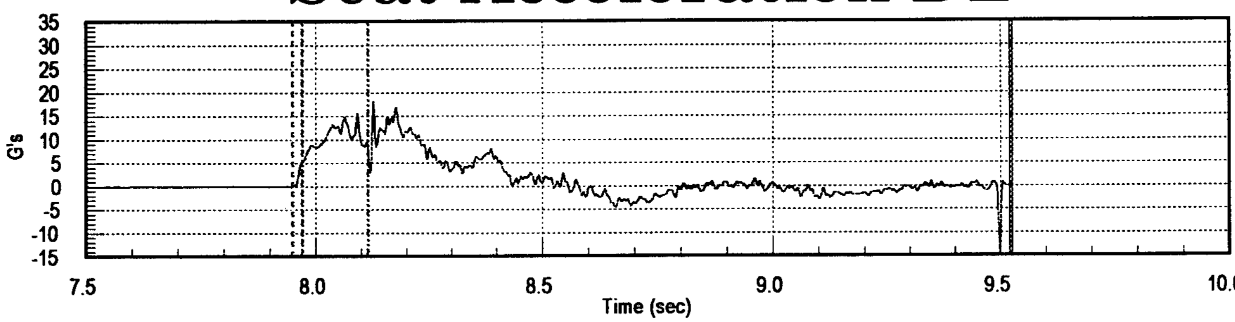
Seat Acceleration DX



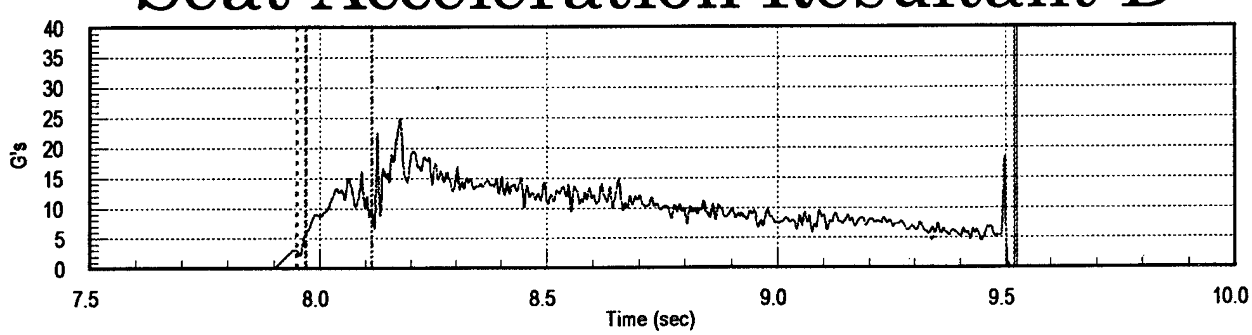
Seat Acceleration DY



Seat Acceleration DZ



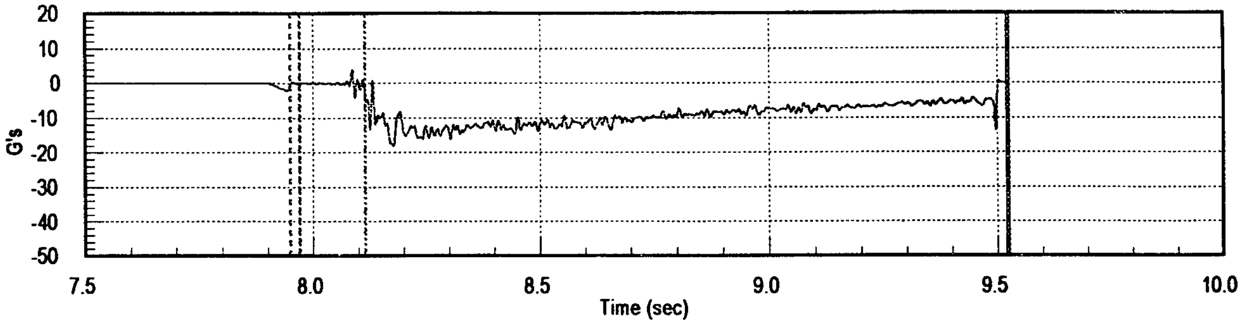
Seat Acceleration Resultant D



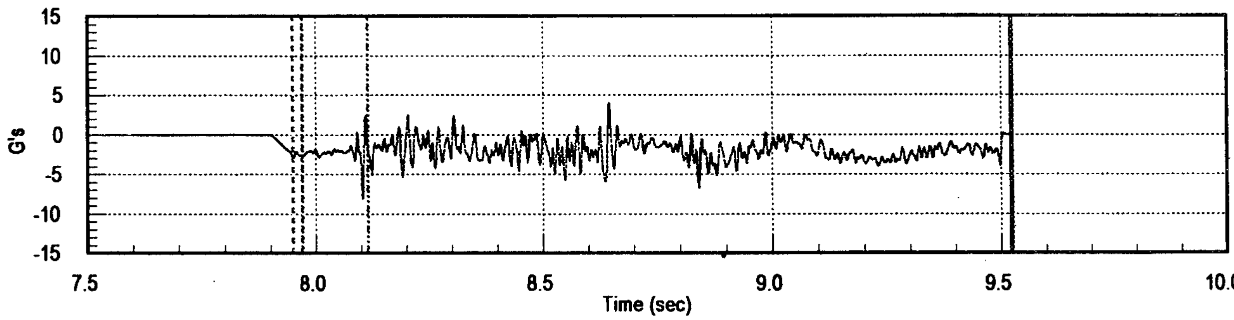
B-13

FL105001, 545 KEAS, 1,800 Ft

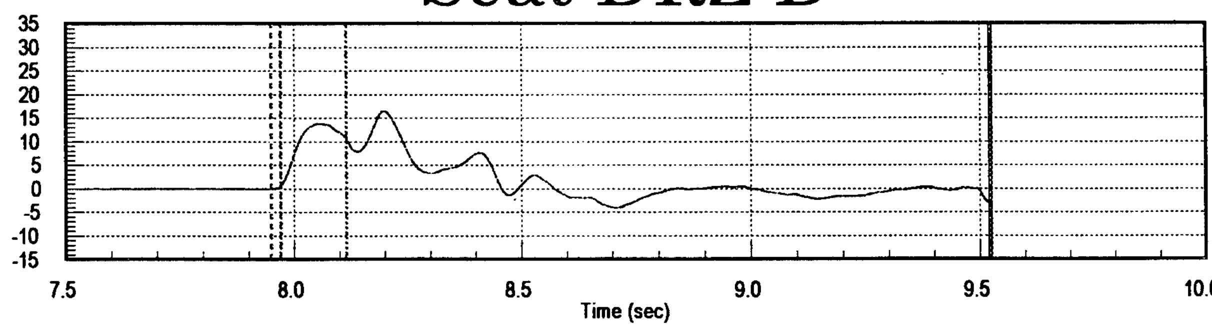
Seat Acceleration DX



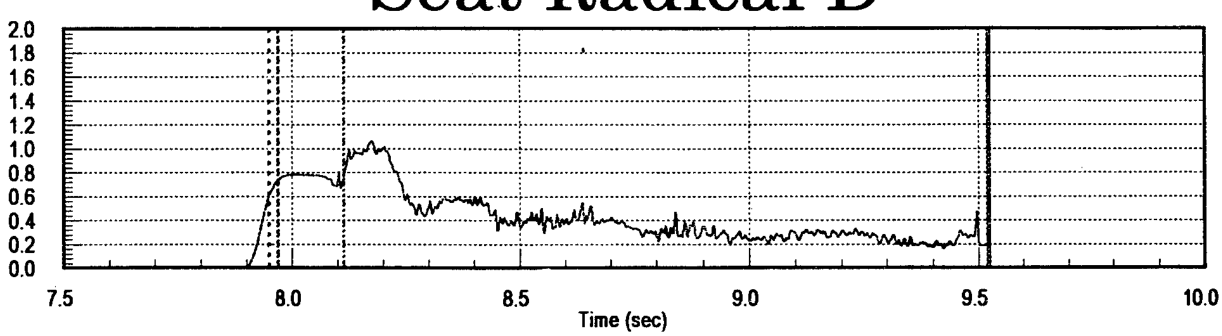
Seat Acceleration DY



Seat DRZ D



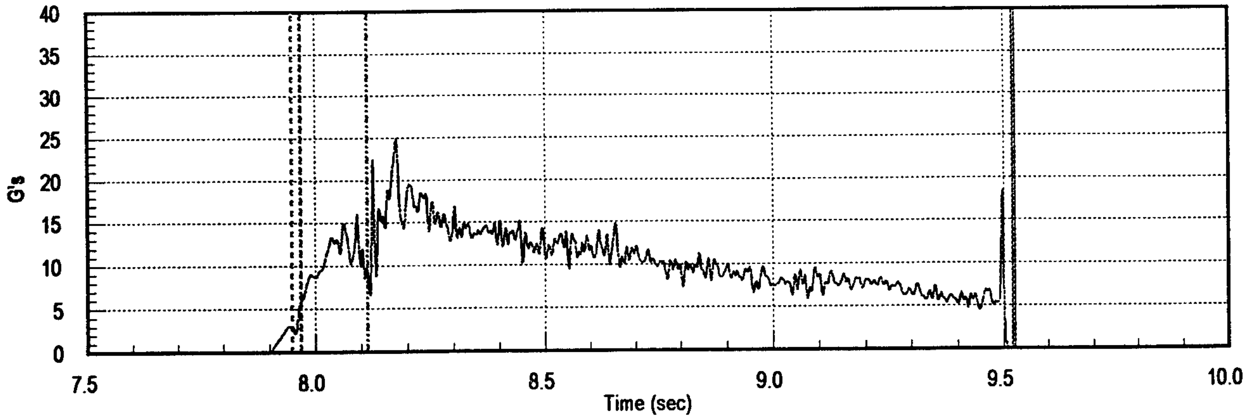
Seat Radical D



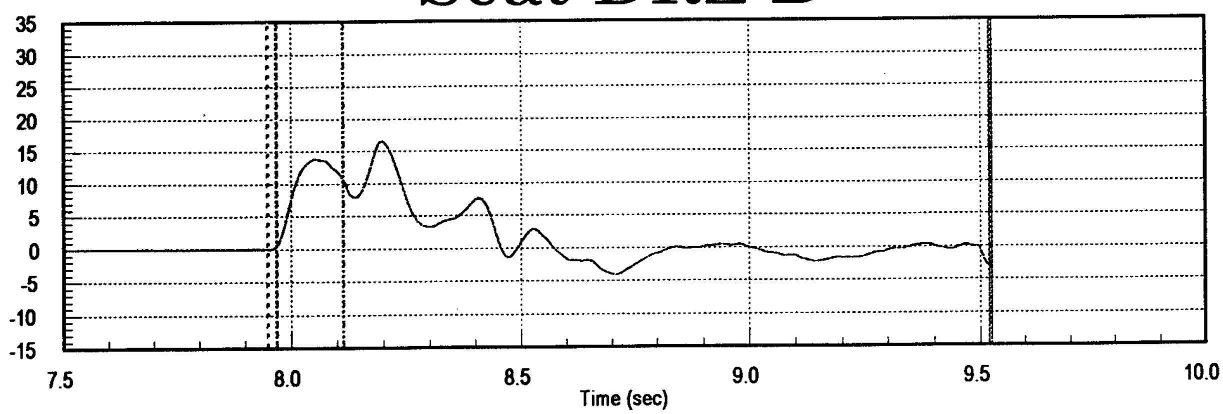
B-14

FL105001, 545 KEAS, 1,800 Ft

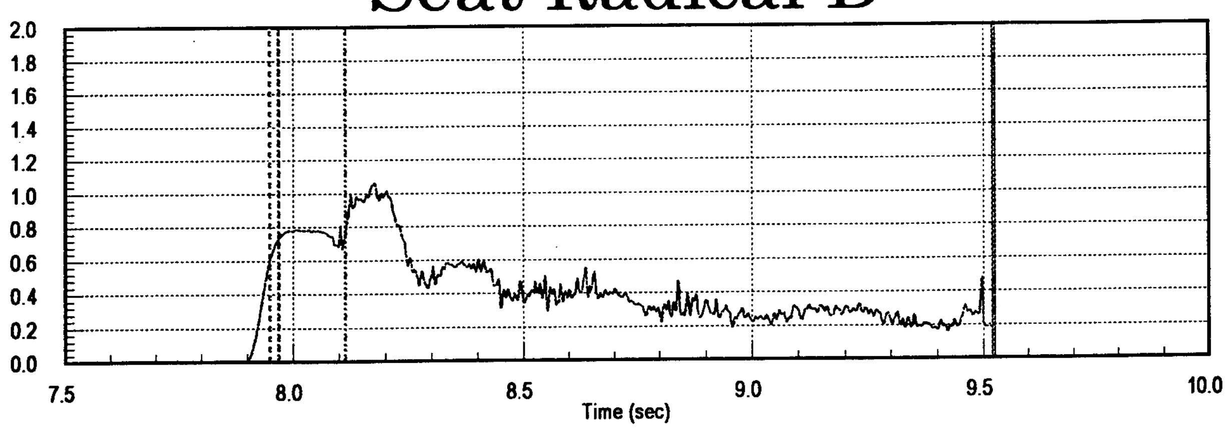
Seat Resultant D



Seat DRZ D

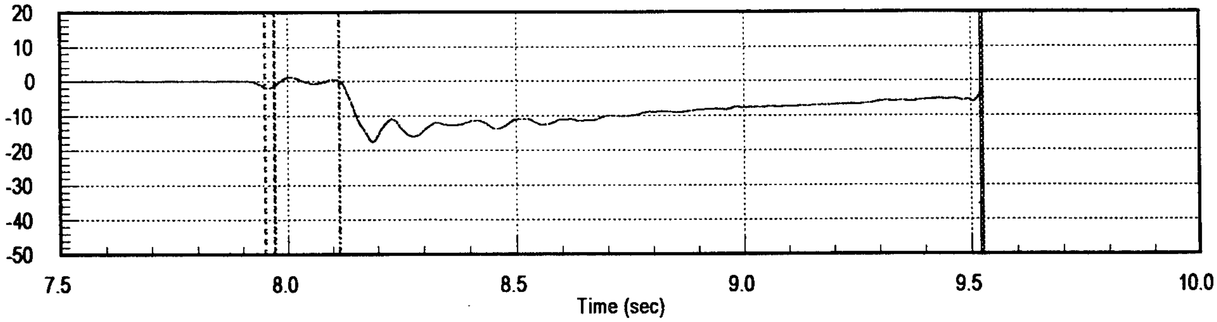


Seat Radical D

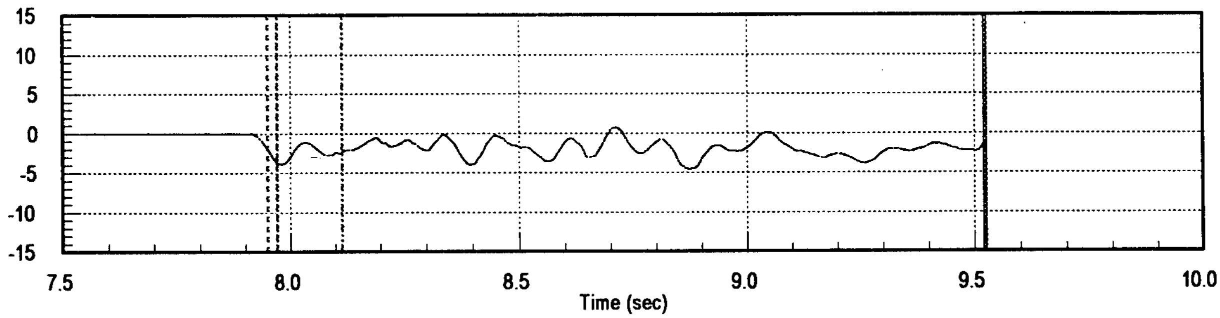


FL105001, 545 KEAS, 1,800 Ft

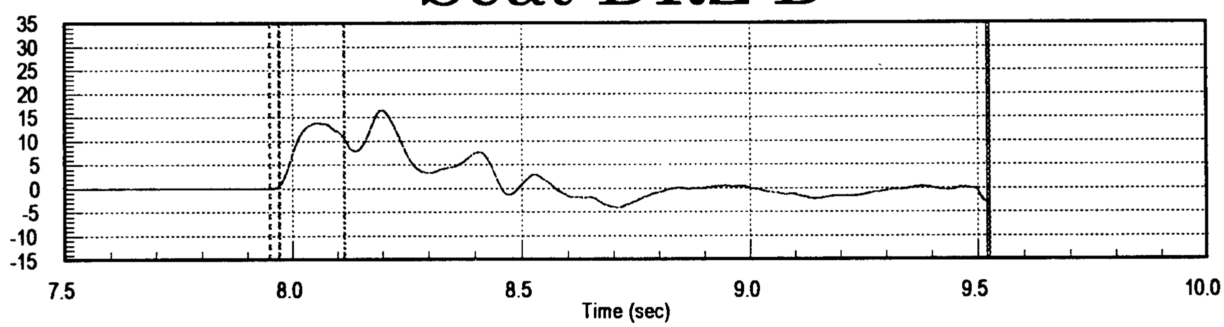
Seat DRX D



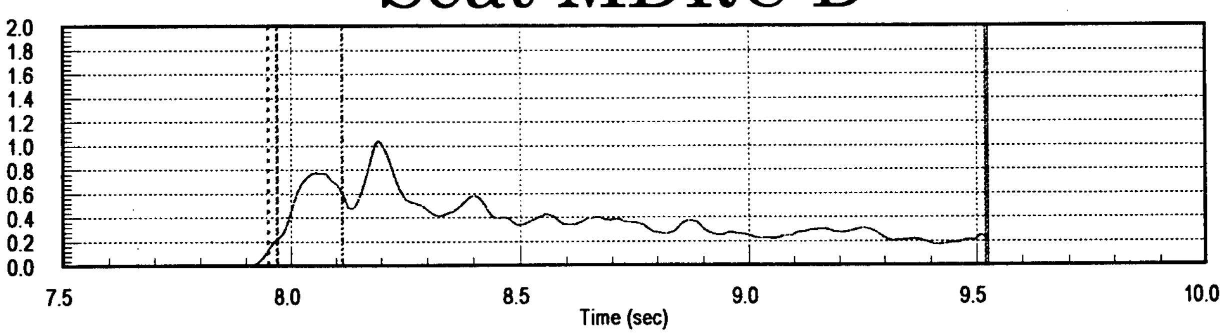
Seat DRY D



Seat DRZ D



Seat MDRC D



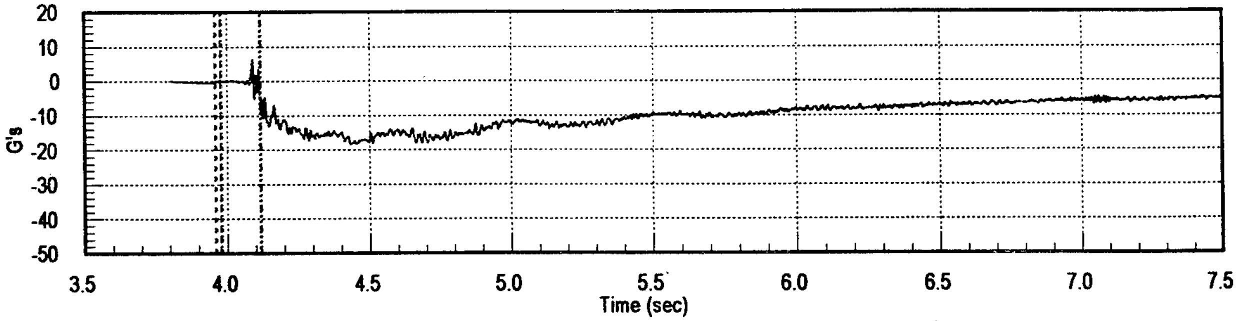
B-16

FL103012, 510 KEAS, 46,000 Ft
Dynamic Response Analysis

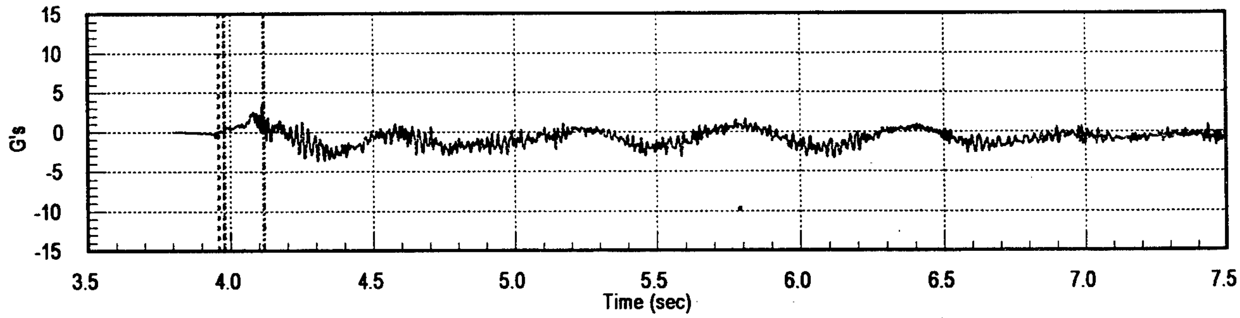
Seat Initiation **Seat 1st Motion** **Boom Firing** **Seat Rail Sep.** **Seat Man Sep.**

FL103012, 510 KEAS, 46,000 Ft

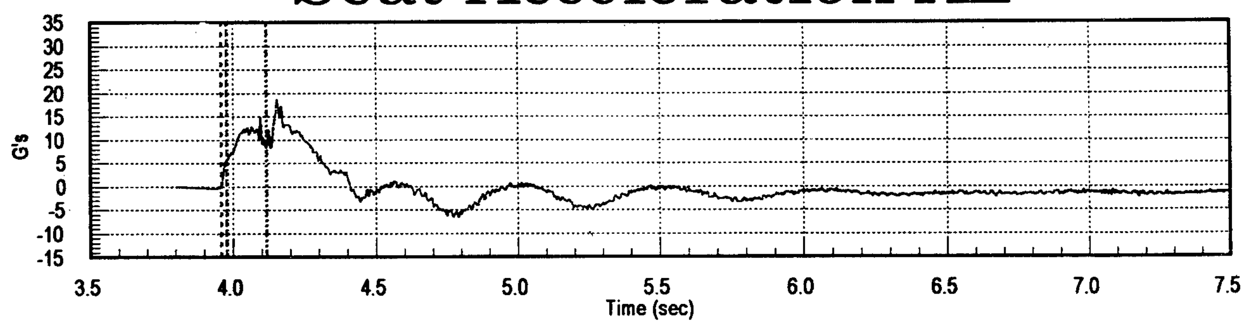
Seat Acceleration AX



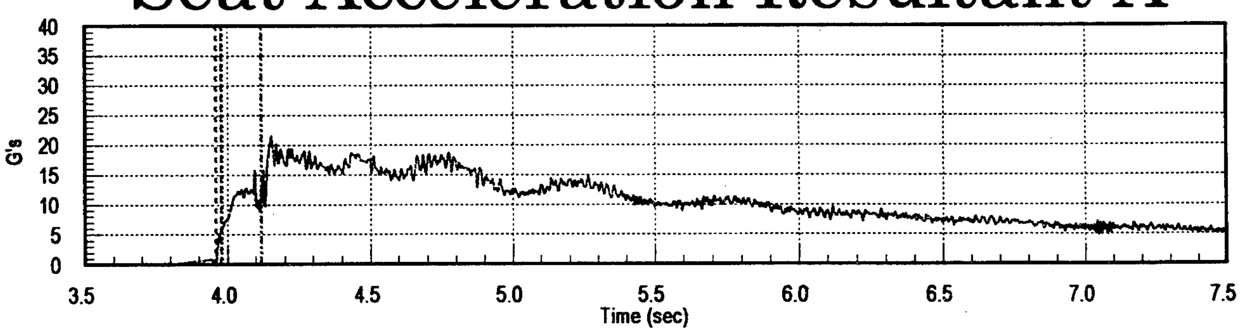
Seat Acceleration AY



Seat Acceleration AZ



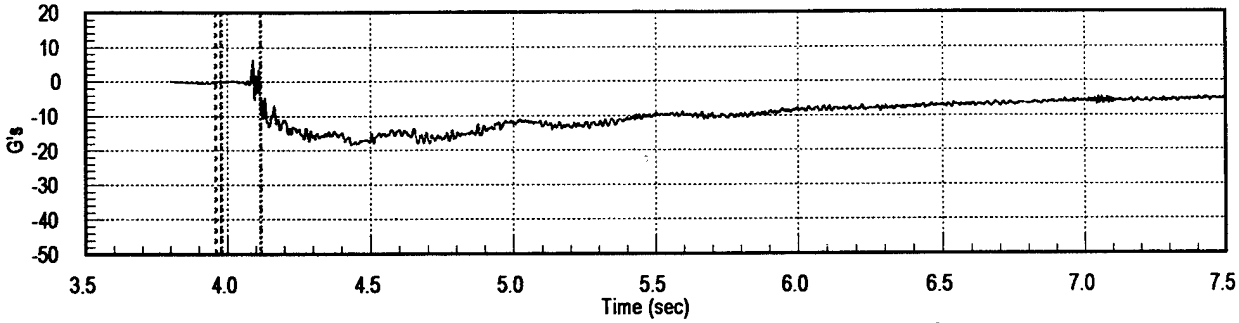
Seat Acceleration Resultant A



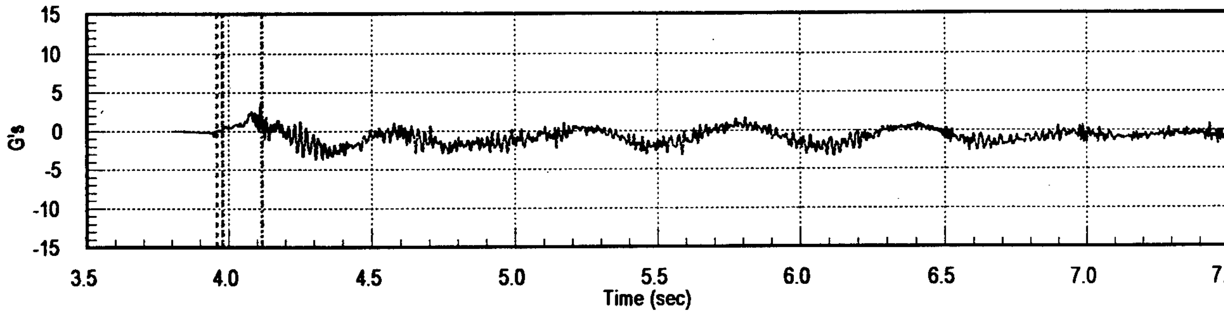
B-1

FL103012, 510 KEAS, 46,000 Ft

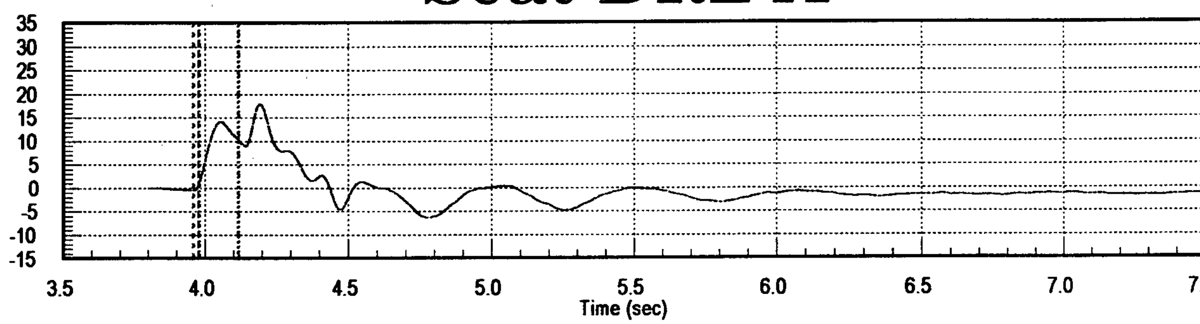
Seat Acceleration AX



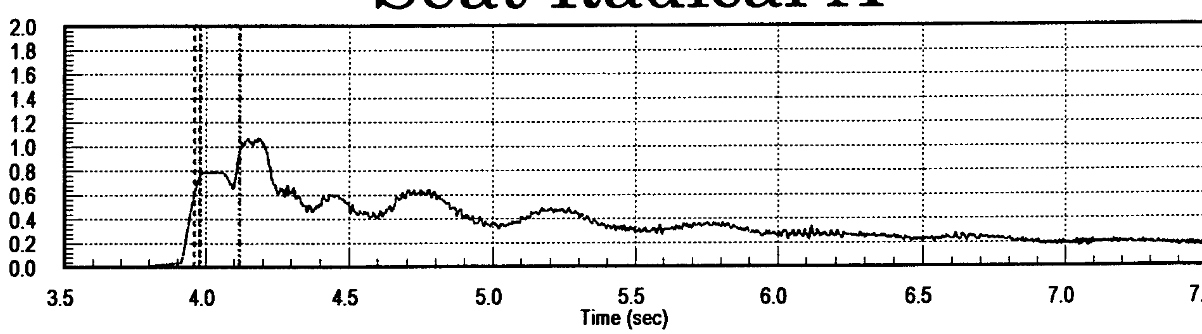
Seat Acceleration AY



Seat DRZ A

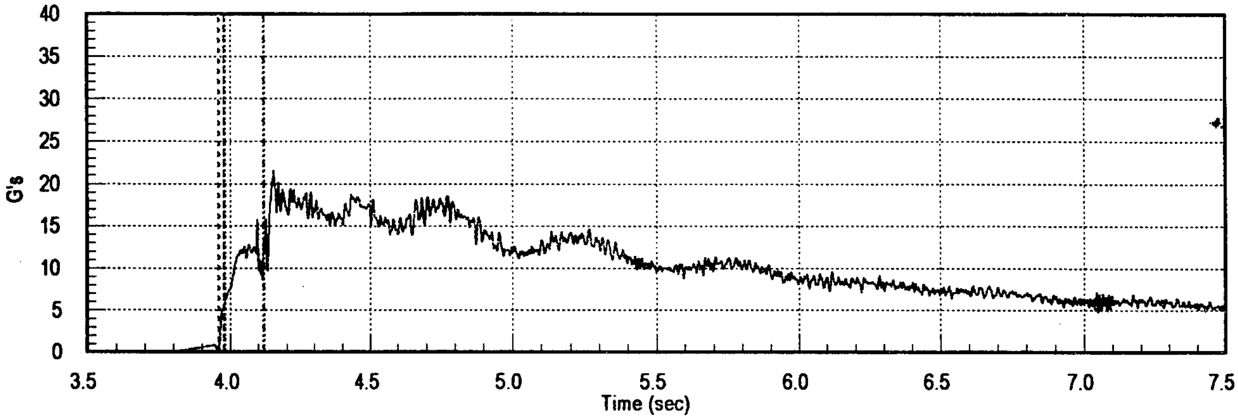


Seat Radical A

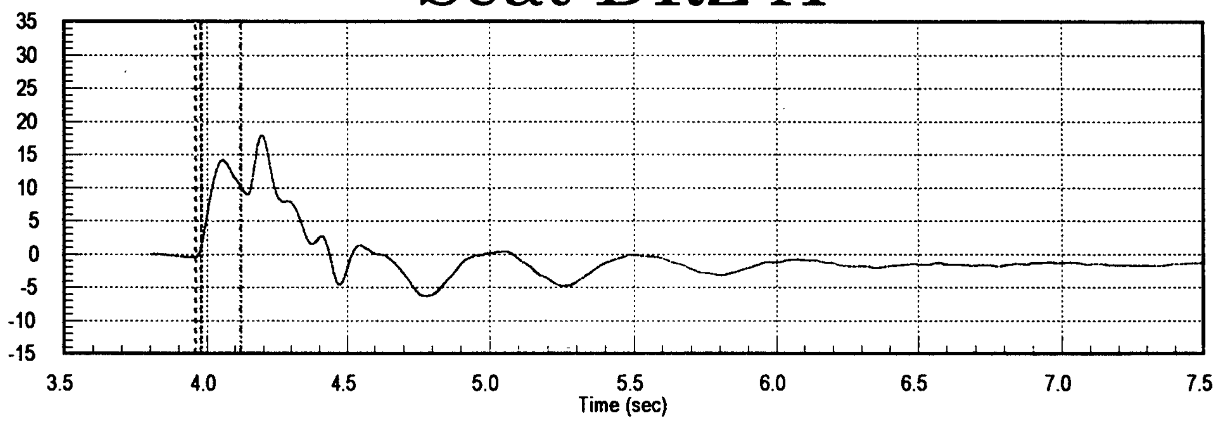


FL103012, 510 KEAS, 46,000 Ft

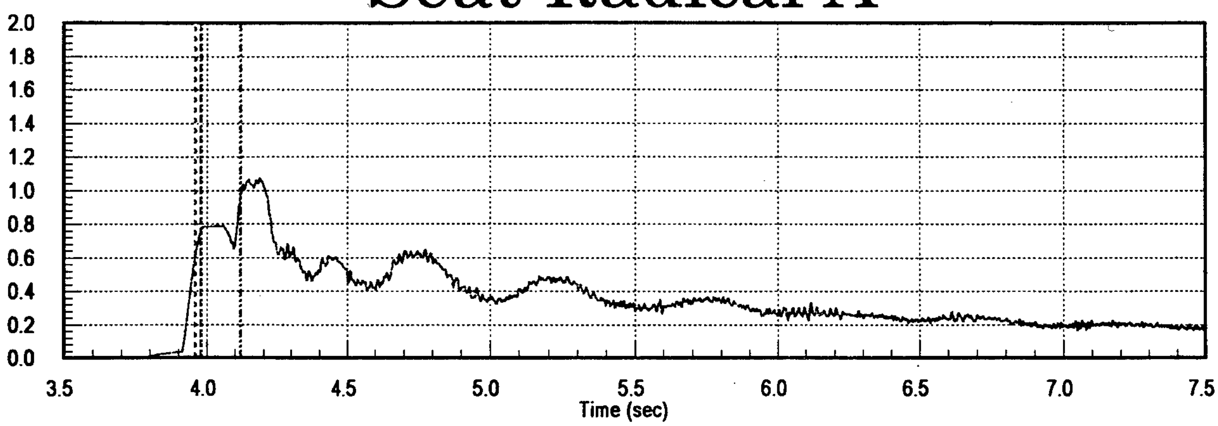
Seat Resultant A



Seat DRZ A



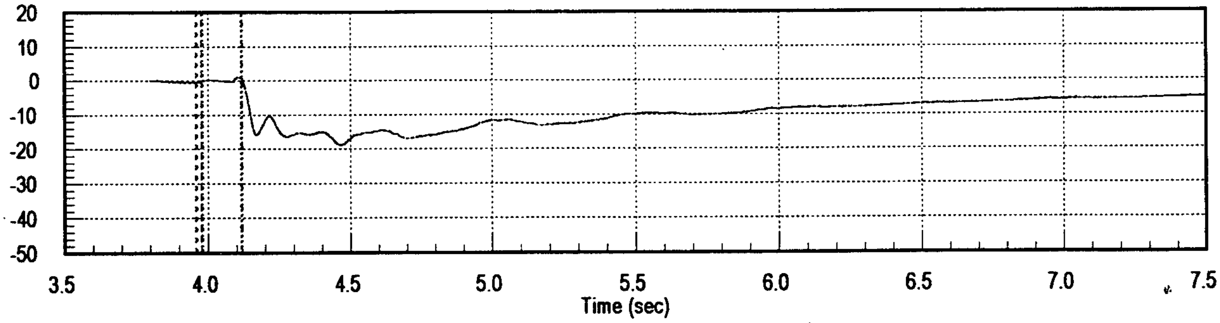
Seat Radical A



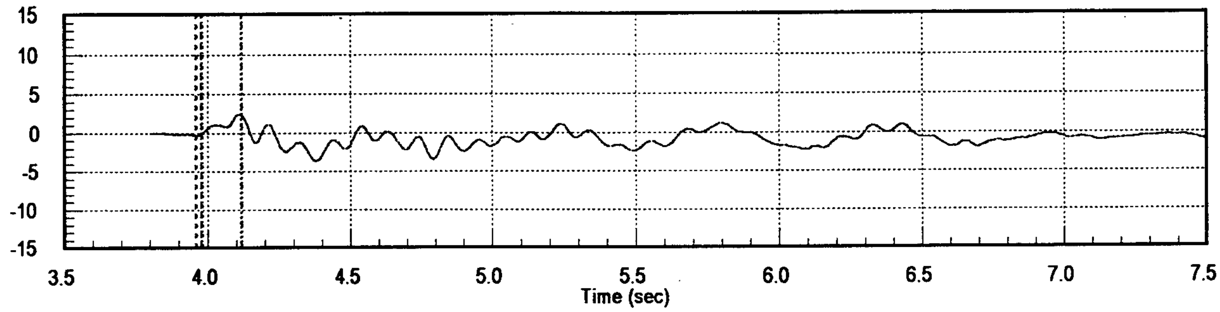
B-3

FL103012, 510 KEAS, 46,000 Ft

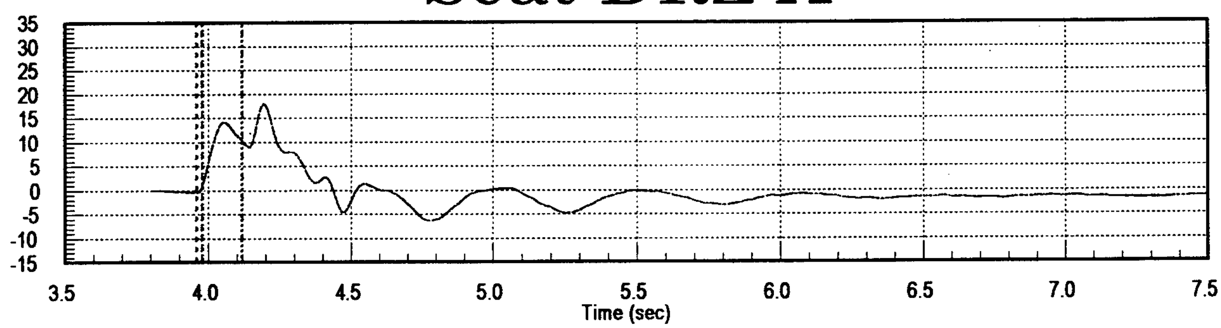
Seat DRX A



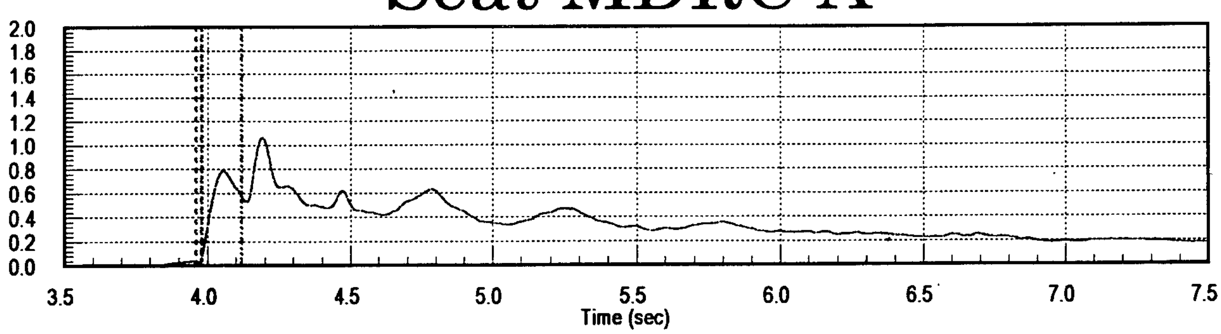
Seat DRY A



Seat DRZ A



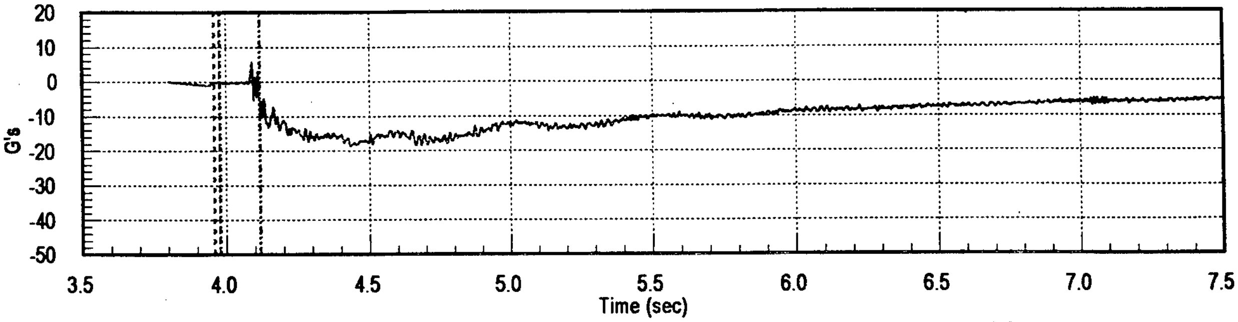
Seat MDRC A



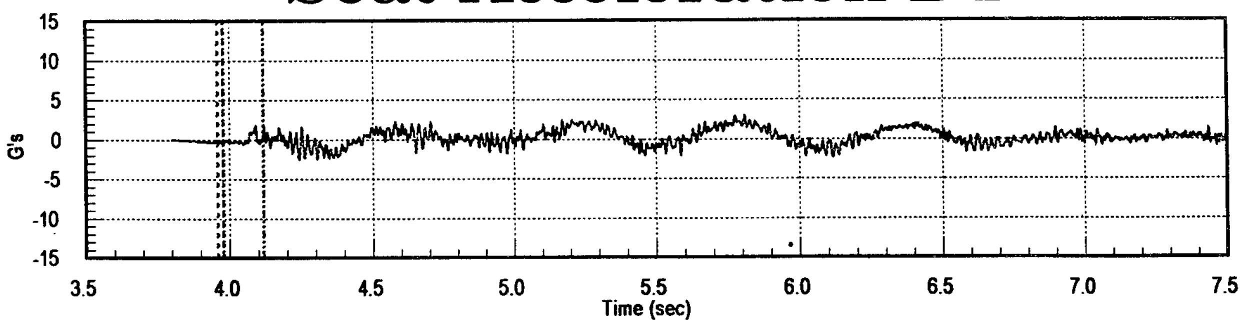
B-4

FL103012, 510 KEAS, 46,000 Ft

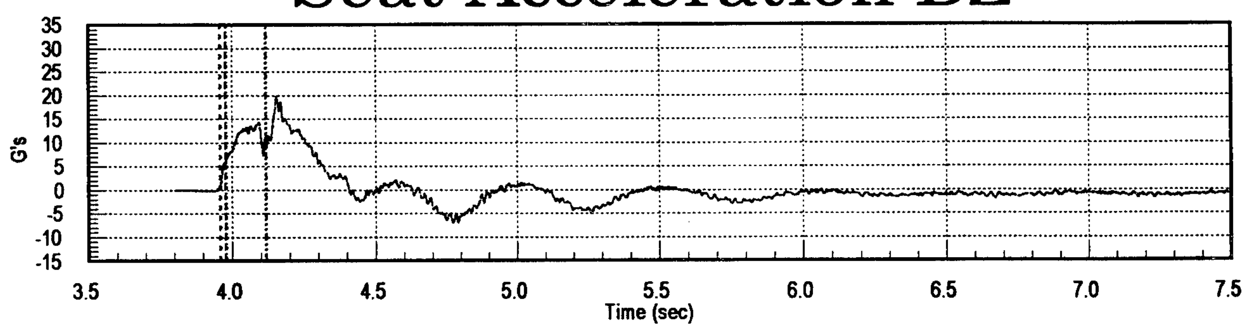
Seat Acceleration BX



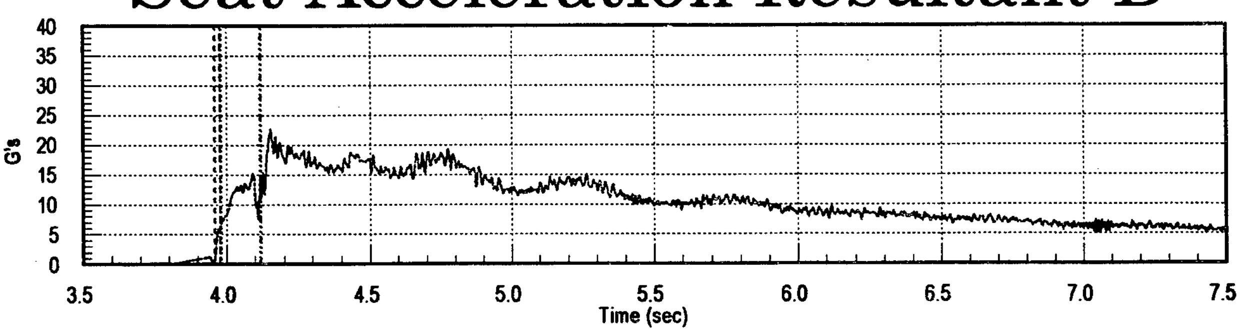
Seat Acceleration BY



Seat Acceleration BZ



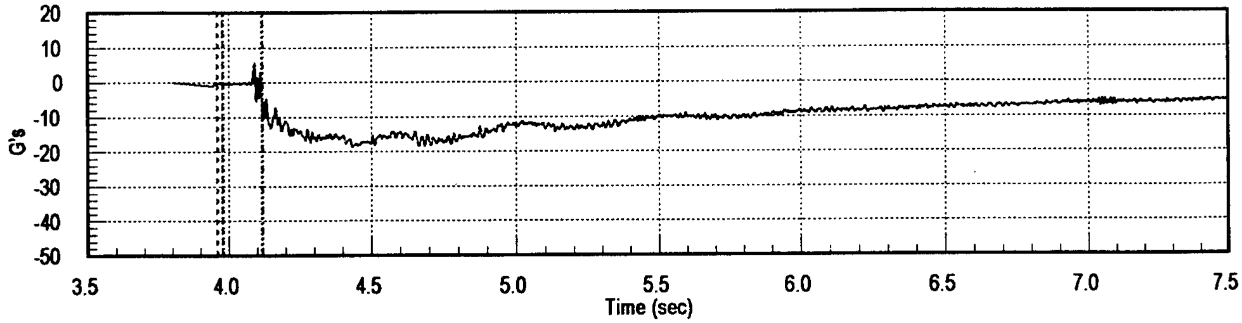
Seat Acceleration Resultant B



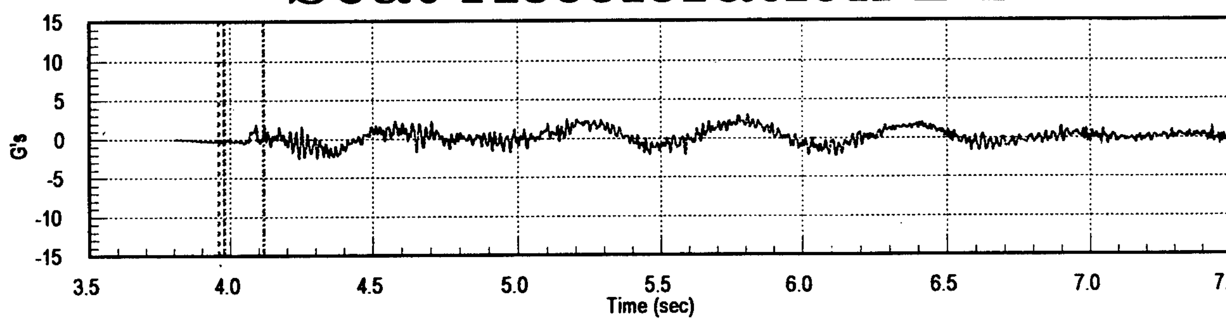
B-5

FL103012, 510 KEAS, 46,000 Ft

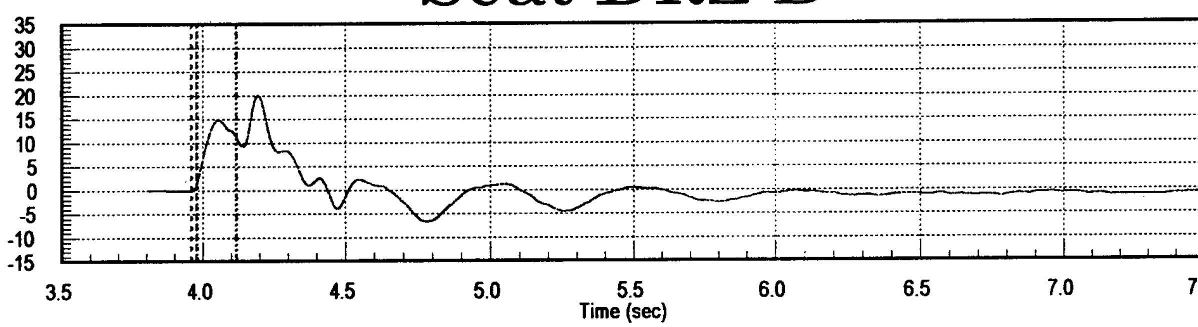
Seat Acceleration BX



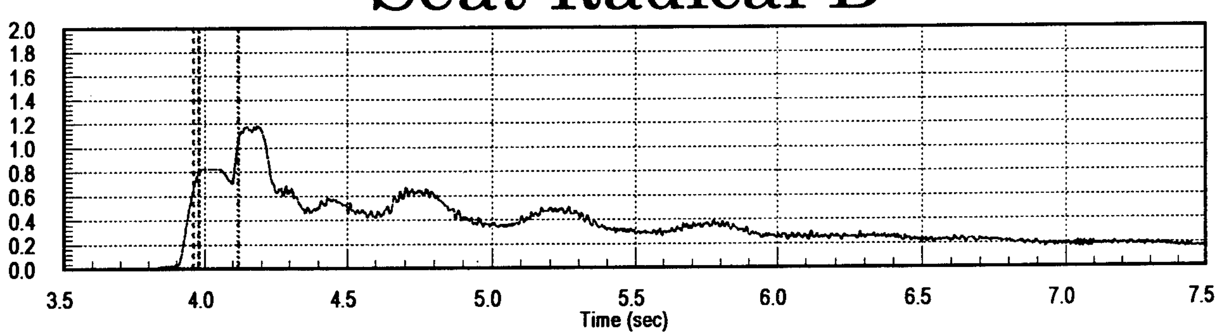
Seat Acceleration BY



Seat DRZ B



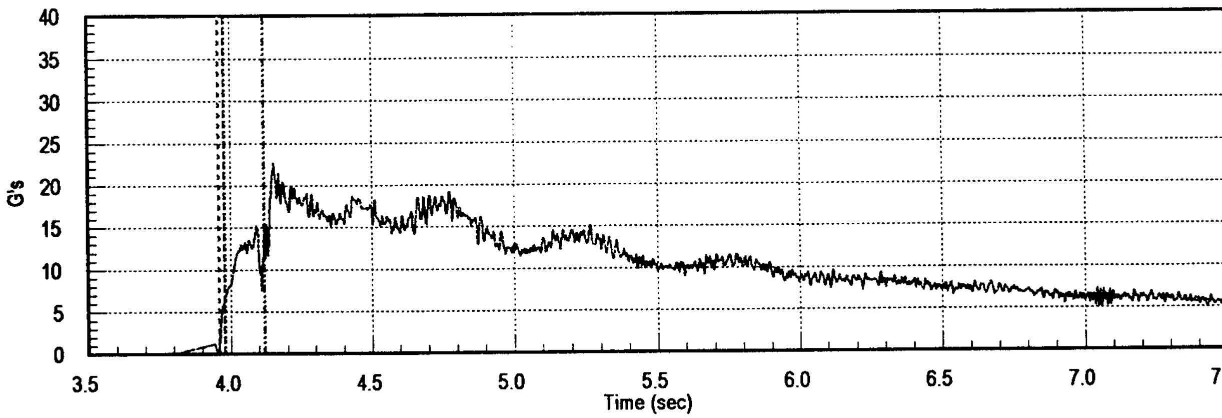
Seat Radical B



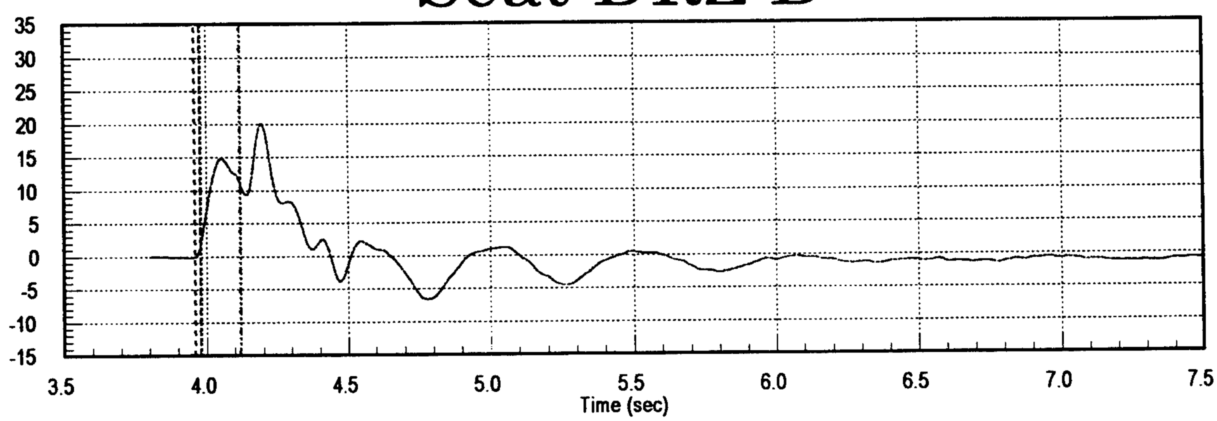
B-6

FL103012, 510 KEAS, 46,000 Ft

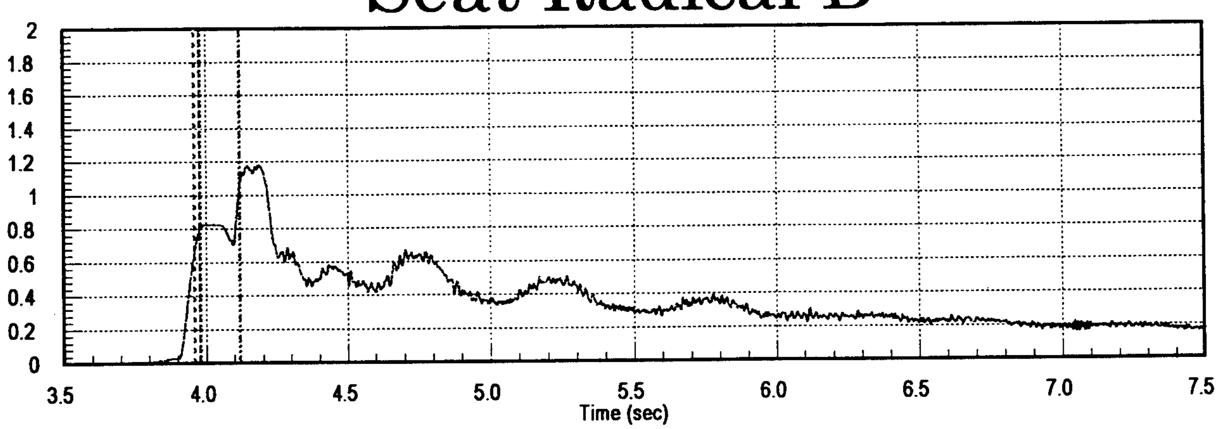
Seat Resultant B



Seat DRZ B



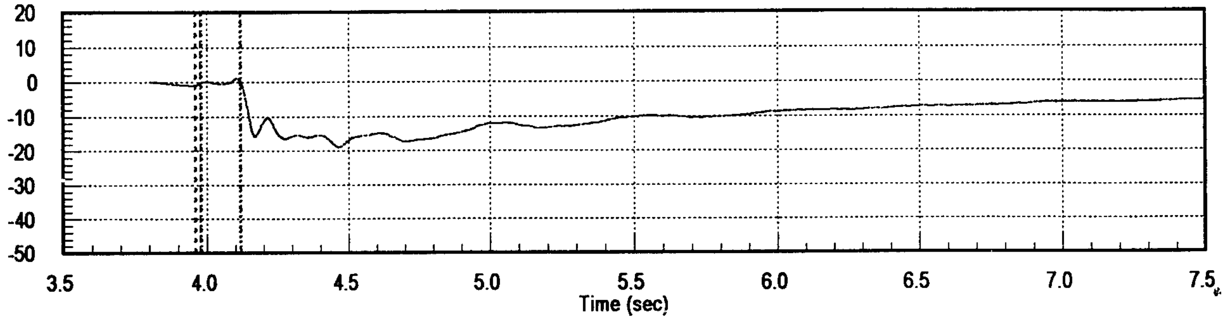
Seat Radical B



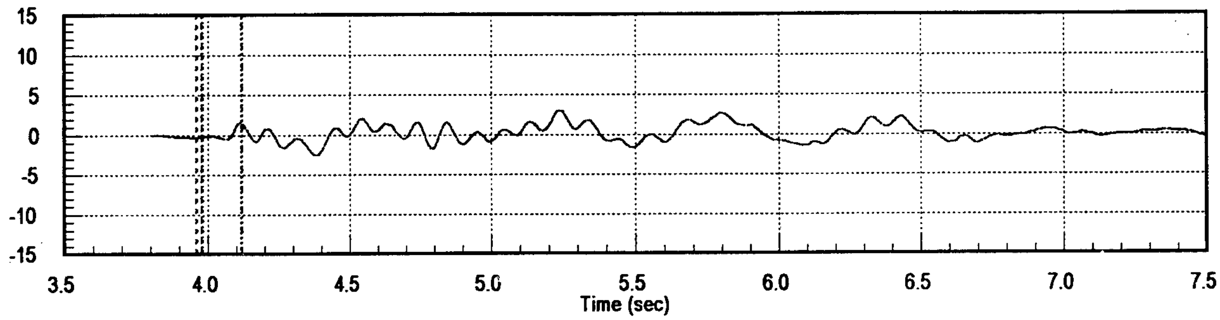
B-7

FL103012, 510 KEAS, 46,000 Ft

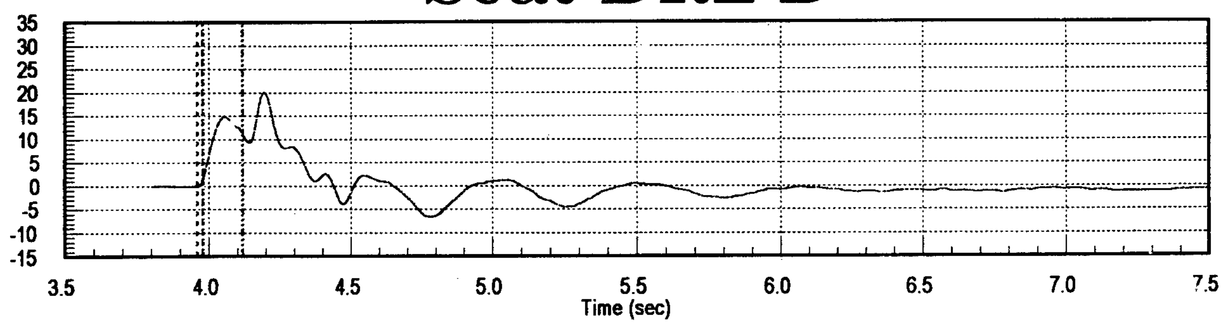
Seat DRX B



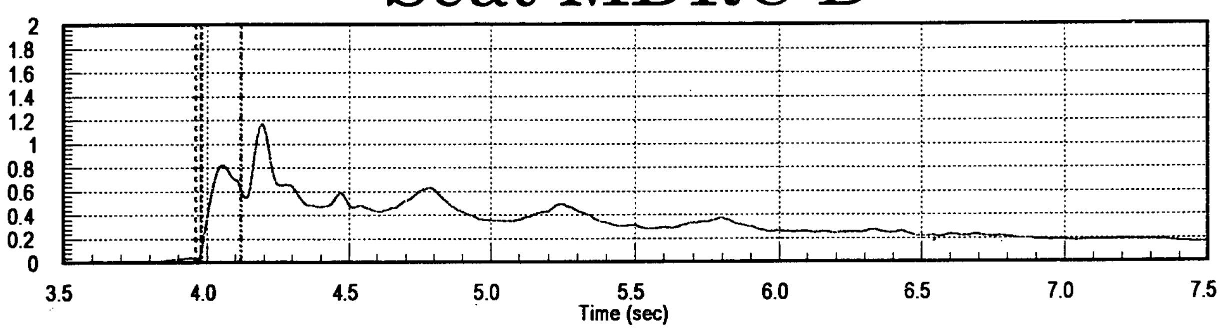
Seat DRY B



Seat DRZ B

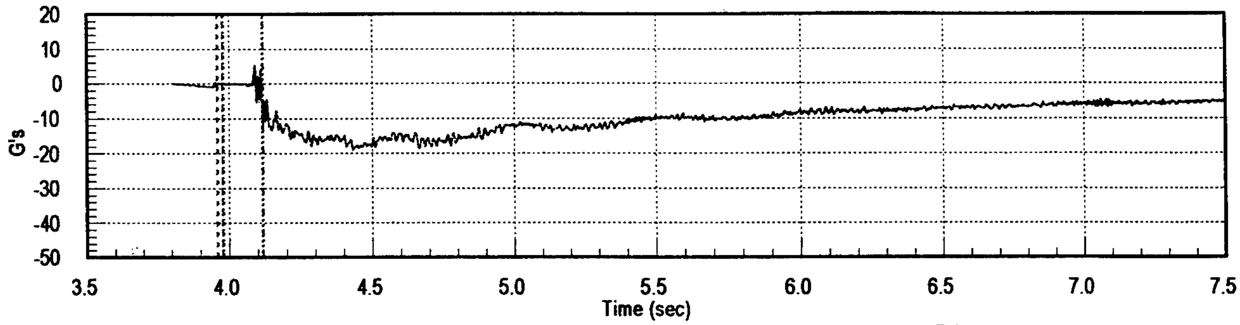


Seat MDRC B

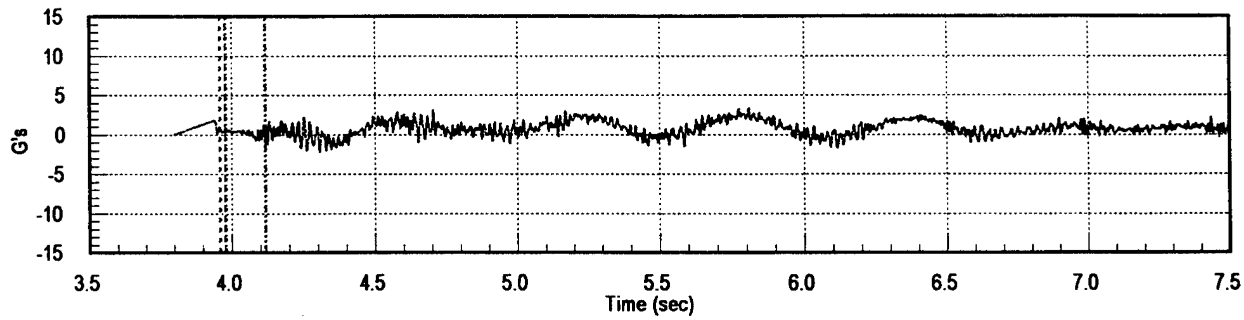


FL103012, 510 KEAS, 46,000 Ft

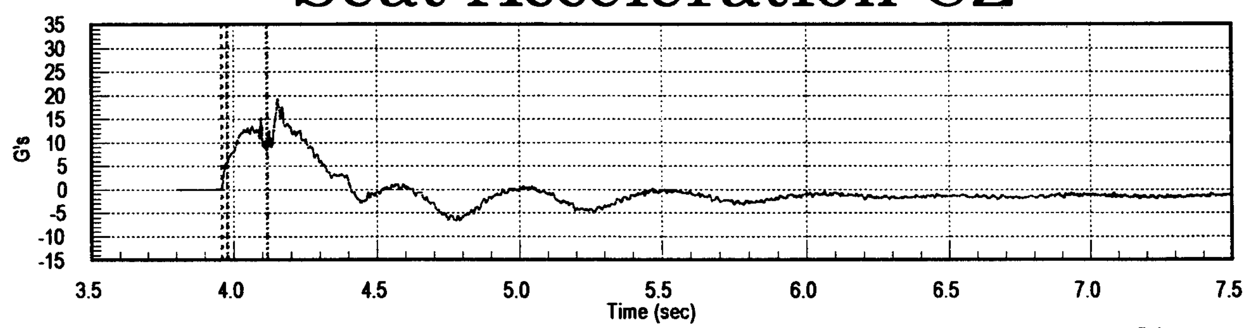
Seat Acceleration CX



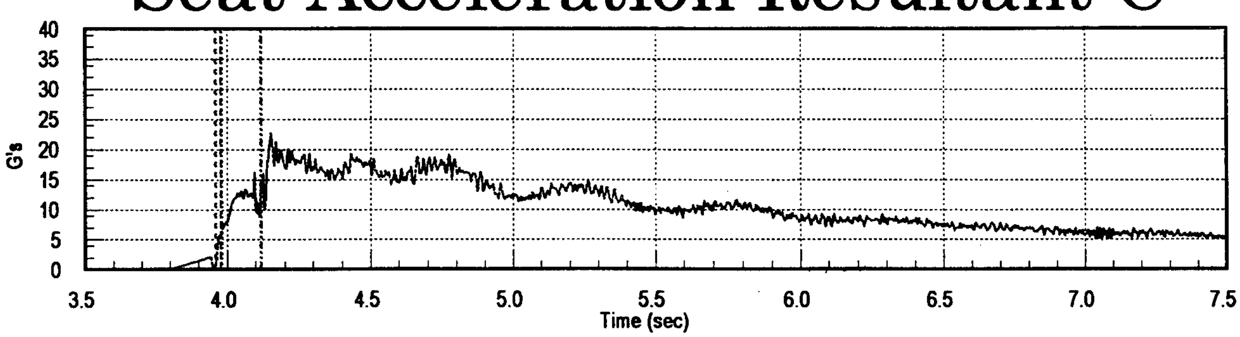
Seat Acceleration CY



Seat Acceleration CZ

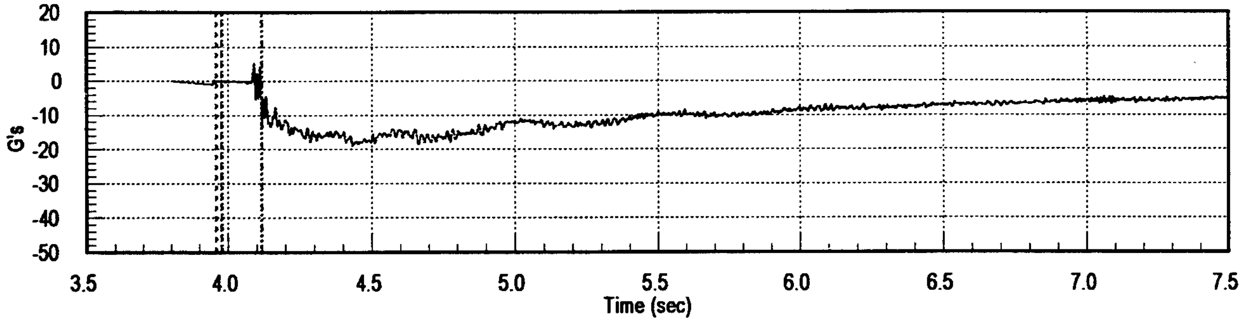


Seat Acceleration Resultant C

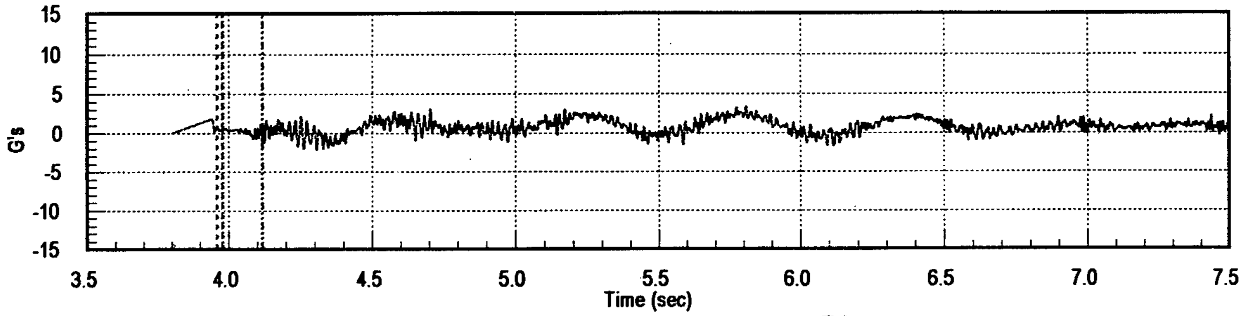


FL103012, 510 KEAS, 46,000 Ft

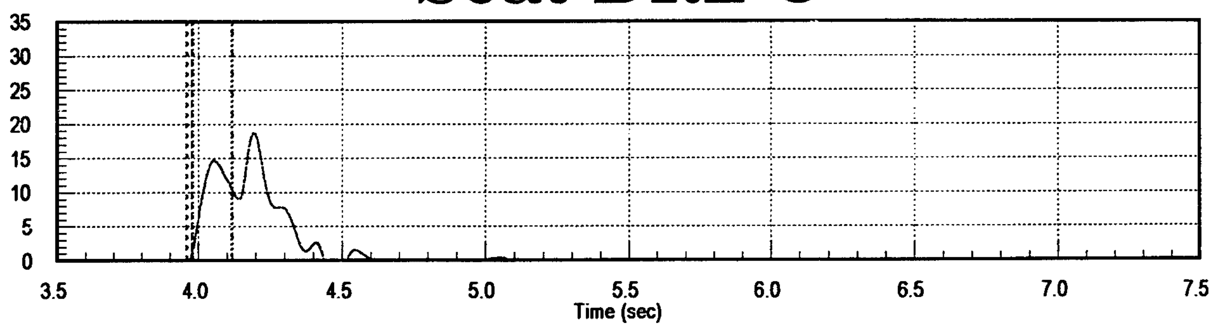
Seat Acceleration CX



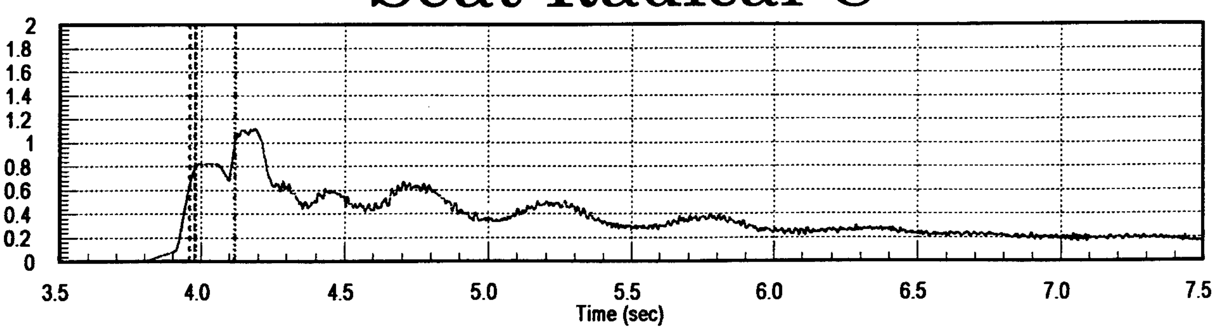
Seat Acceleration CY



Seat DRZ C

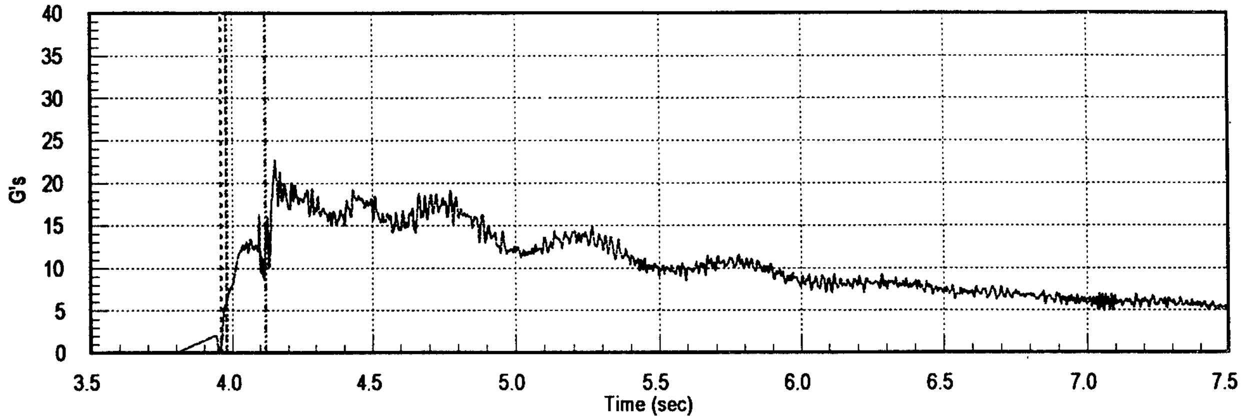


Seat Radical C

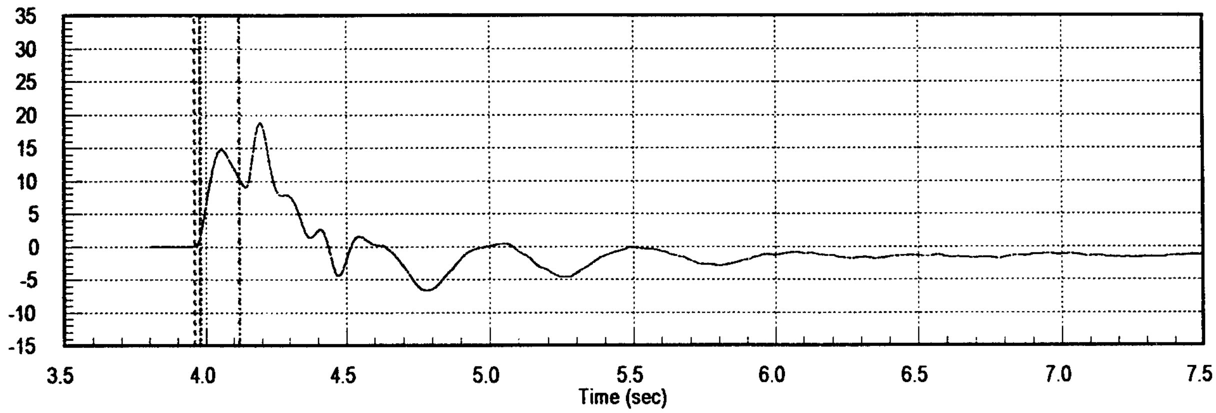


FL103012, 510 KEAS, 46,000 Ft

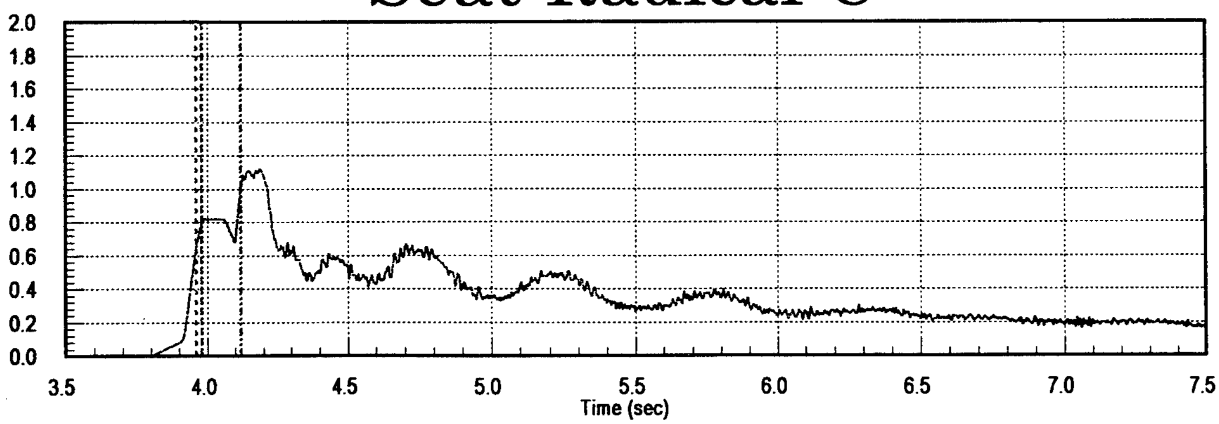
Seat Resultant C



Seat DRZ C



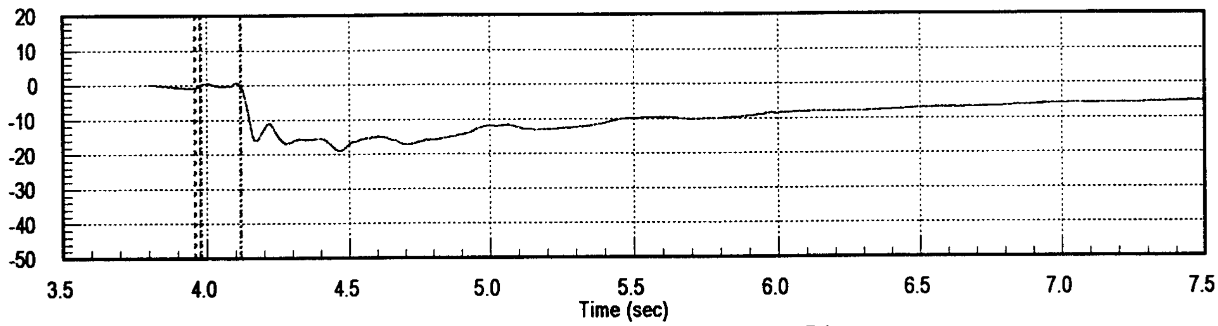
Seat Radical C



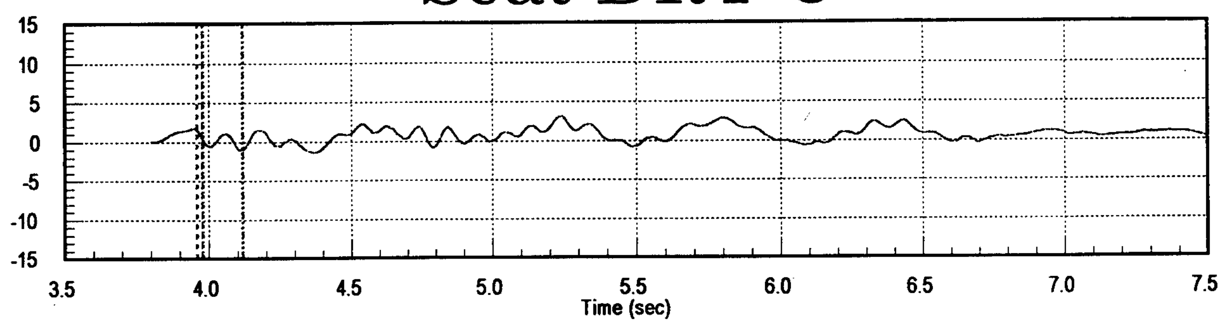
B-11

FL103012, 510 KEAS, 46,000 Ft

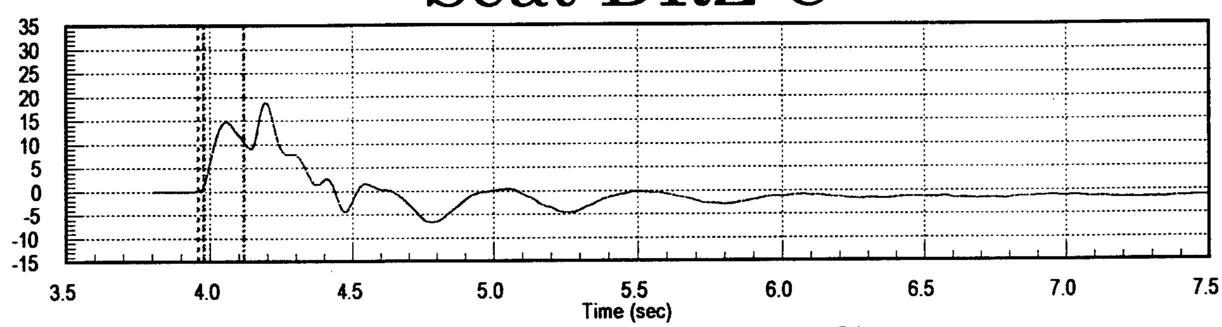
Seat DRX C



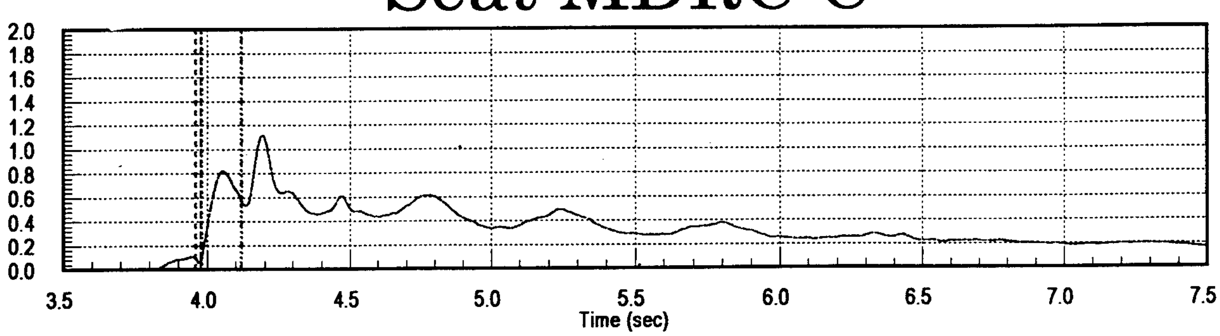
Seat DRY C



Seat DRZ C

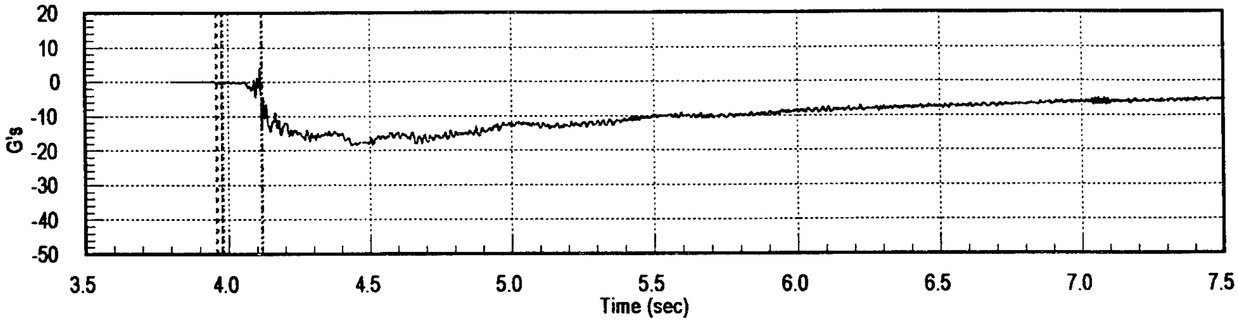


Seat MDRC C

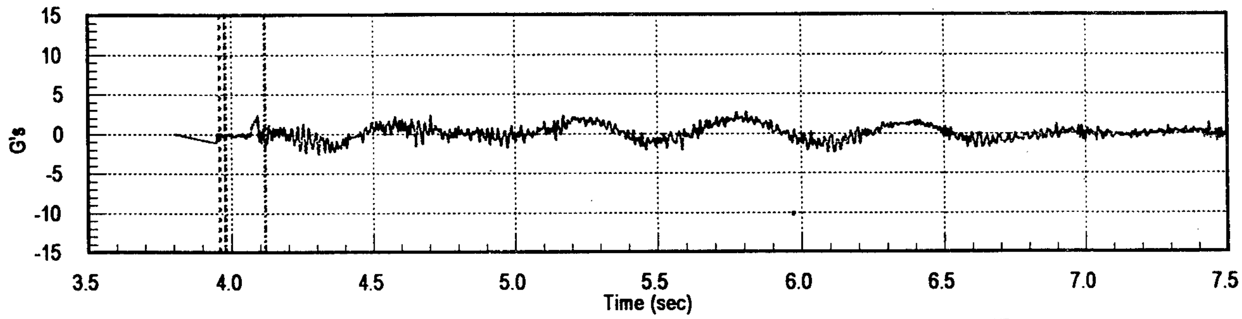


FL103012, 510 KEAS, 46,000 Ft

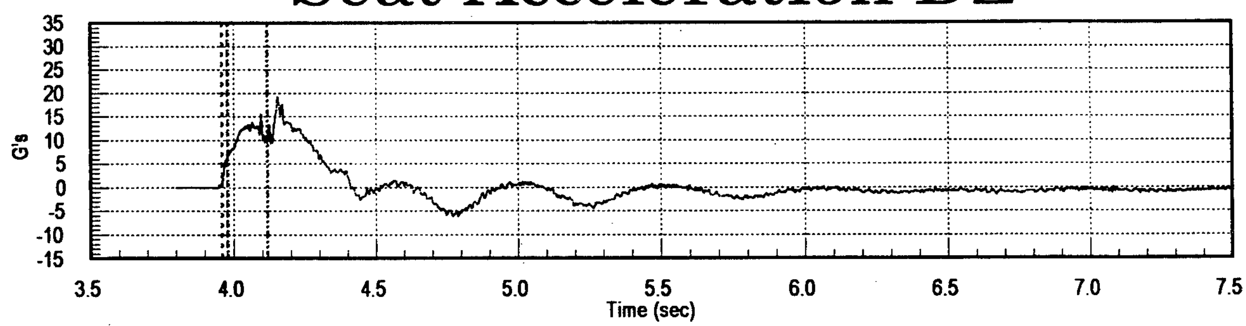
Seat Acceleration DX



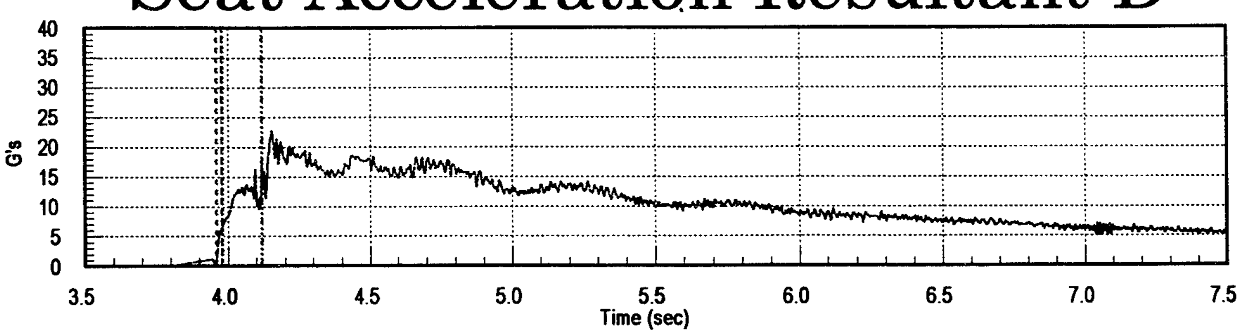
Seat Acceleration DY



Seat Acceleration DZ



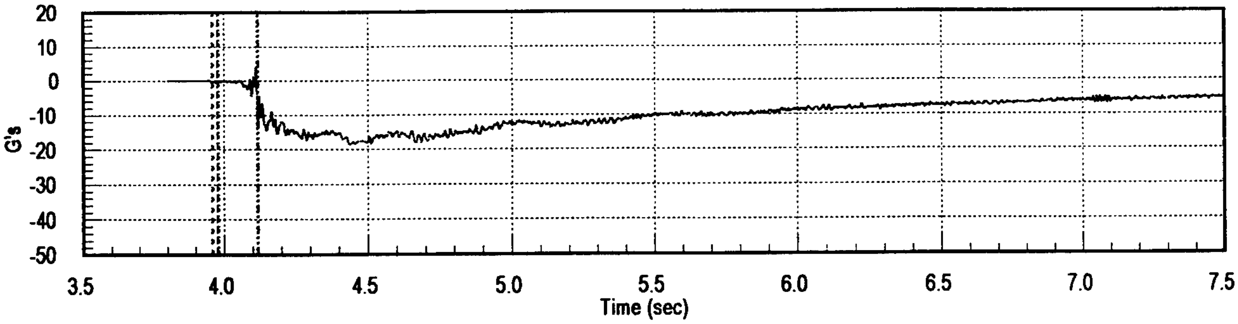
Seat Acceleration Resultant D



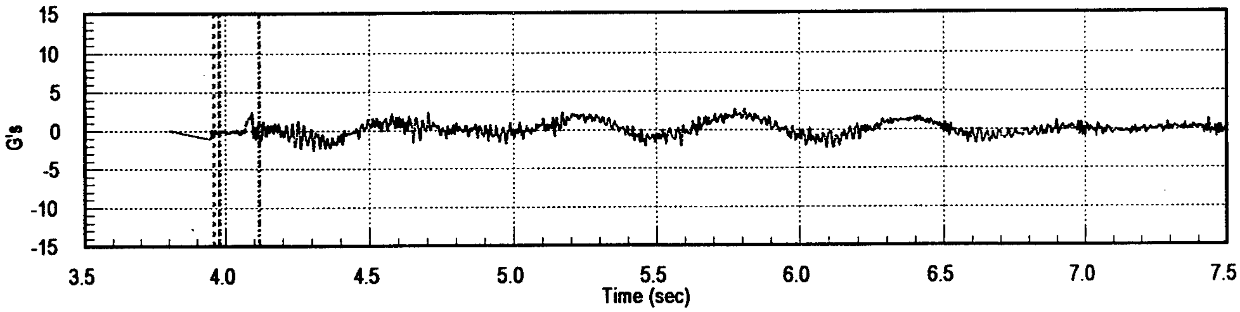
B-13

FL103012, 510 KEAS, 46,000 Ft

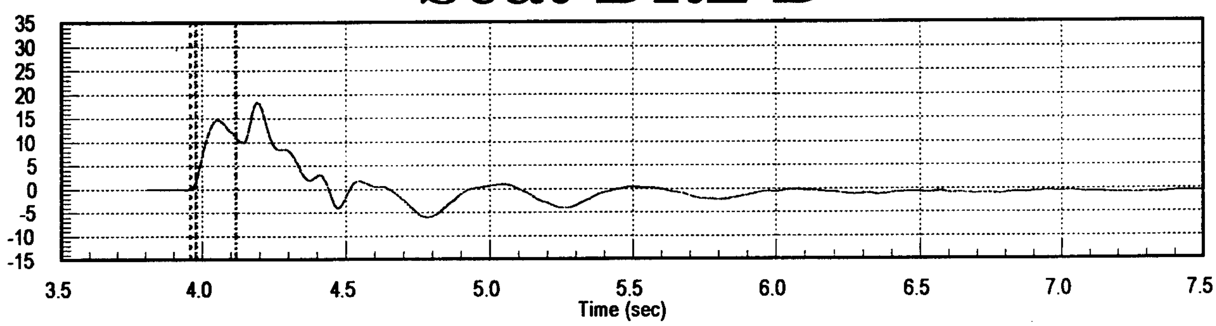
Seat Acceleration DX



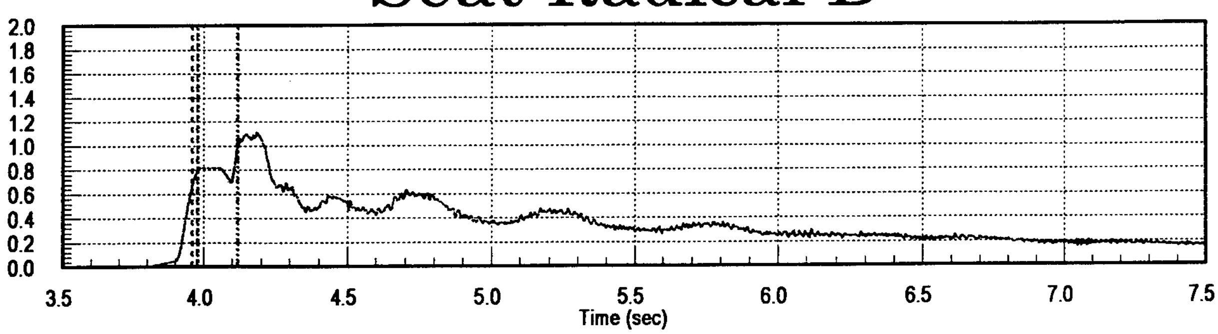
Seat Acceleration DY



Seat DRZ D

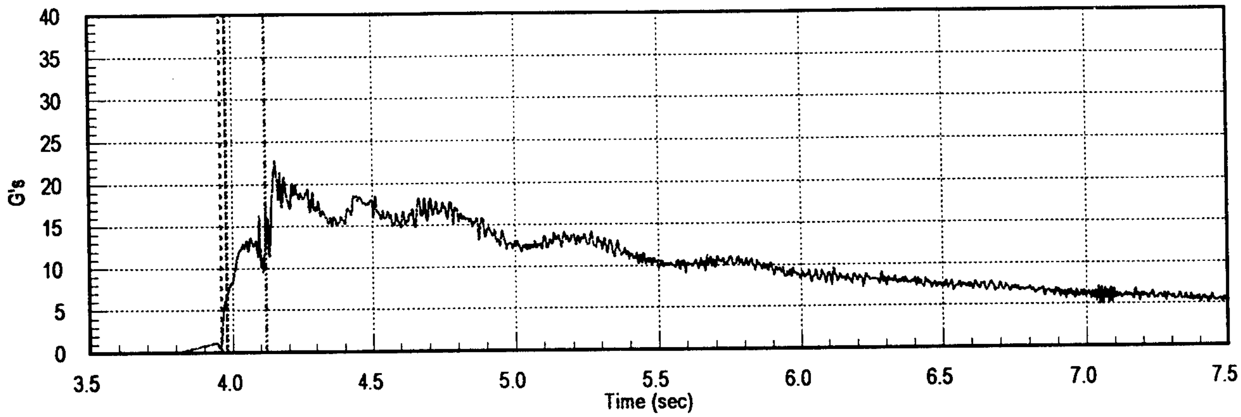


Seat Radical D

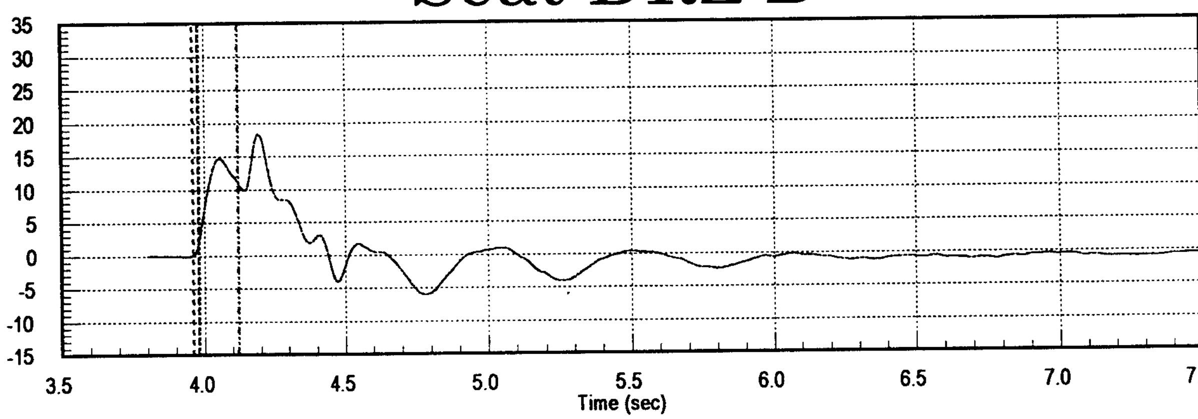


FL103012, 510 KEAS, 46,000 Ft

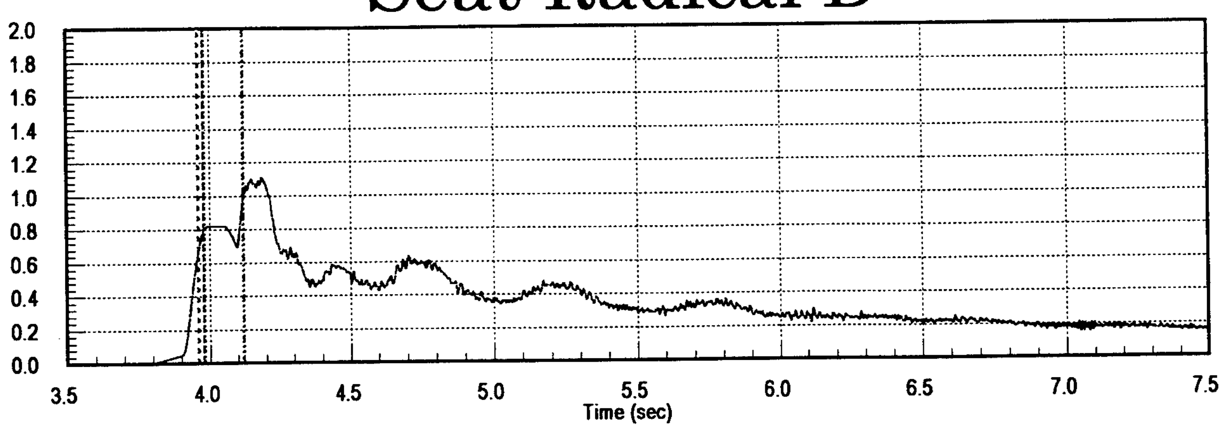
Seat Resultant D



Seat DRZ D



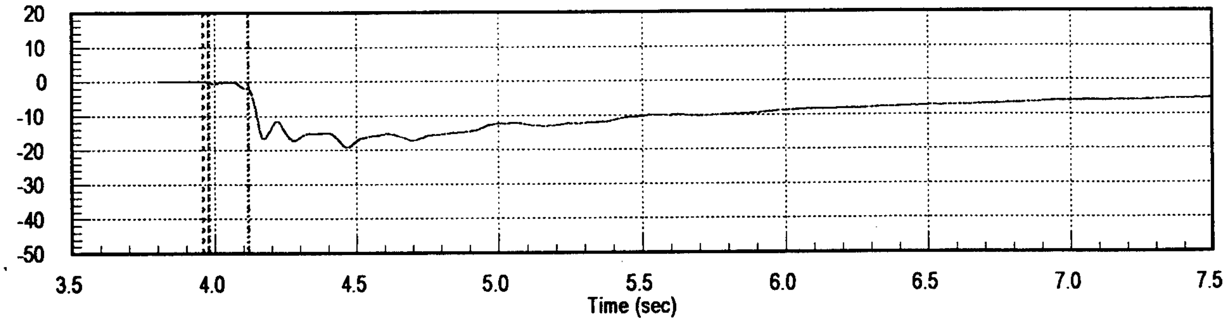
Seat Radical D



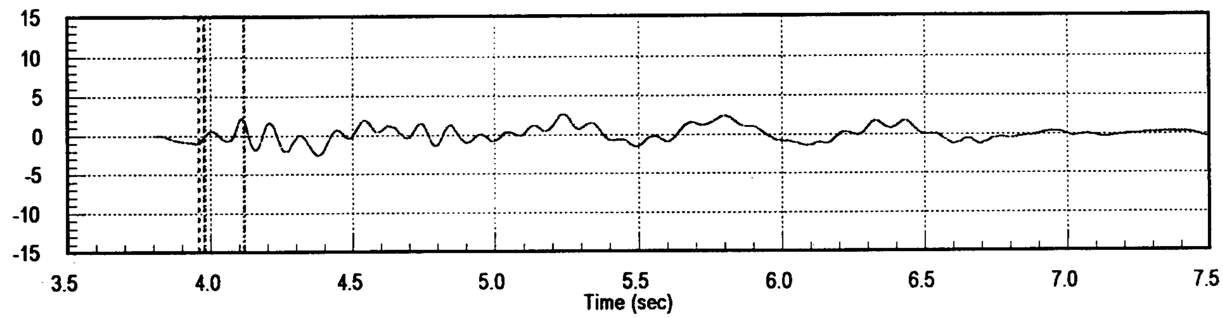
B-15

FL103012, 510 KEAS, 46,000 Ft

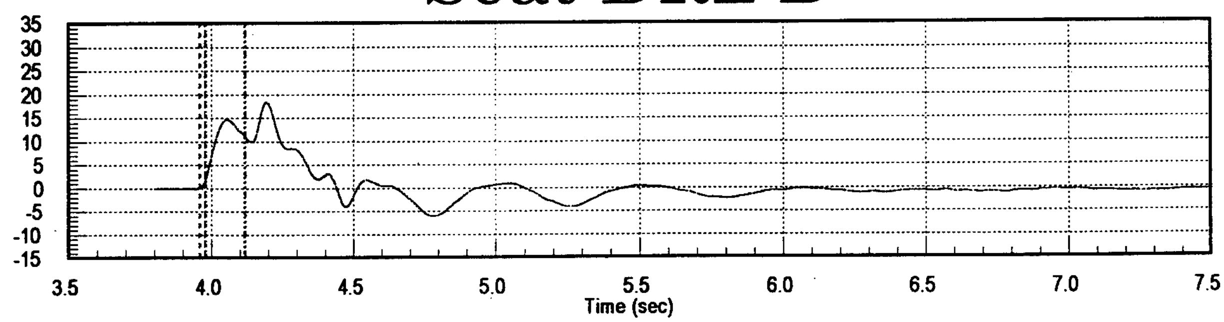
Seat DRX D



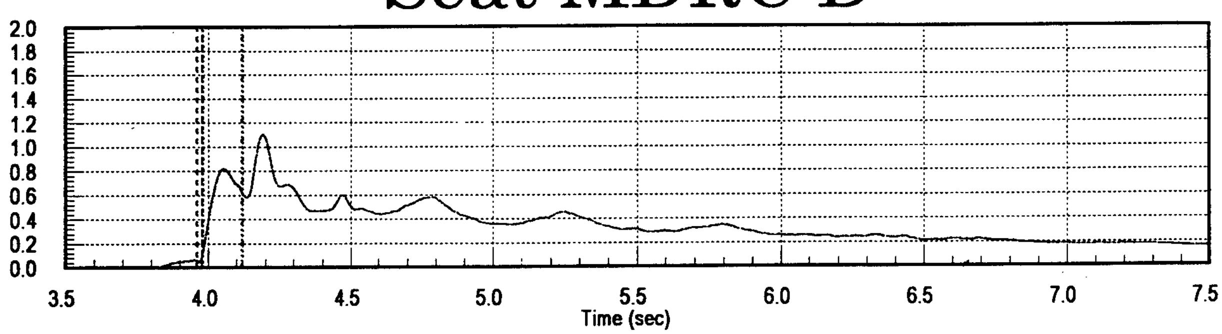
Seat DRY D



Seat DRZ D



Seat MDRC D

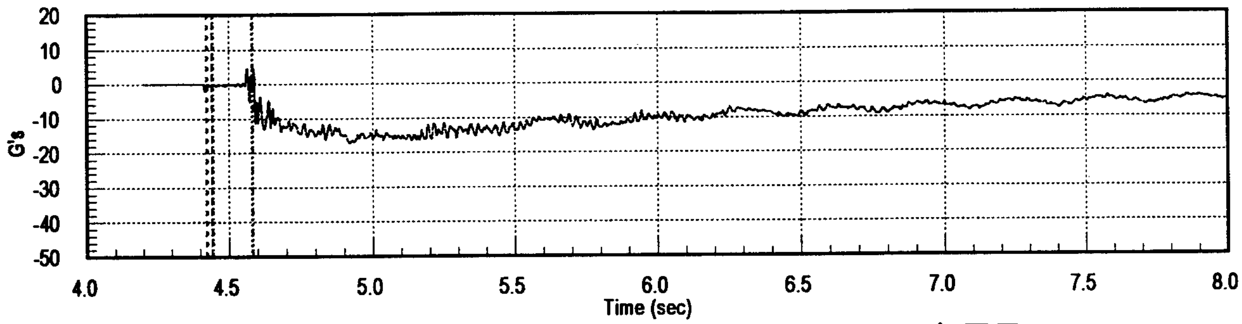


FL097516, 480 KEAS, 56,000 Ft
Dynamic Response Analysis

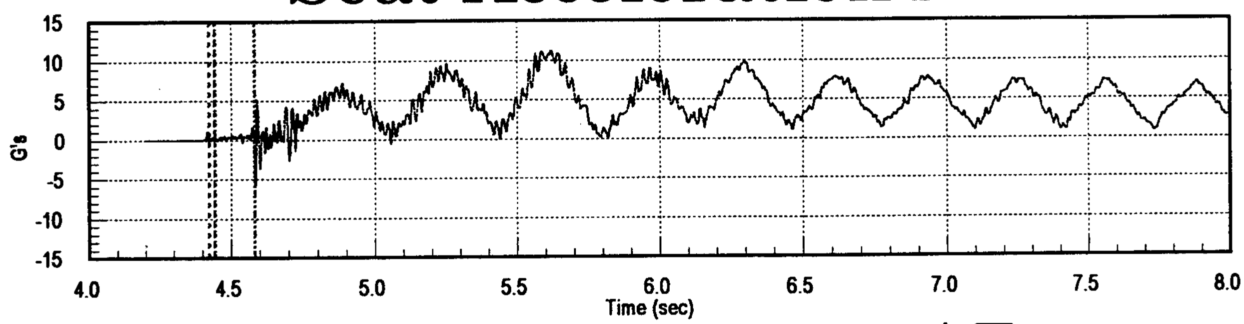
Seat Initiation	Seat 1st Motion	Boom Firing	Seat Rail Sep.	Seat Man Sep.

FL097516, 480 KEAS, 56,000 Ft

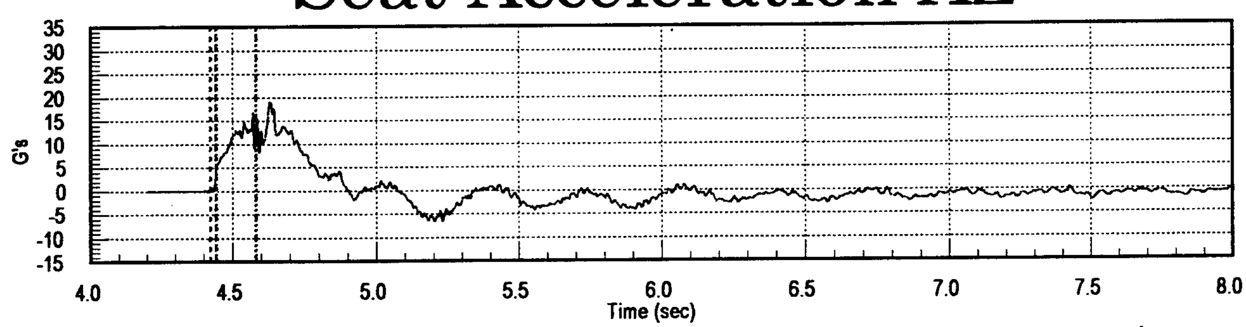
Seat Acceleration AX



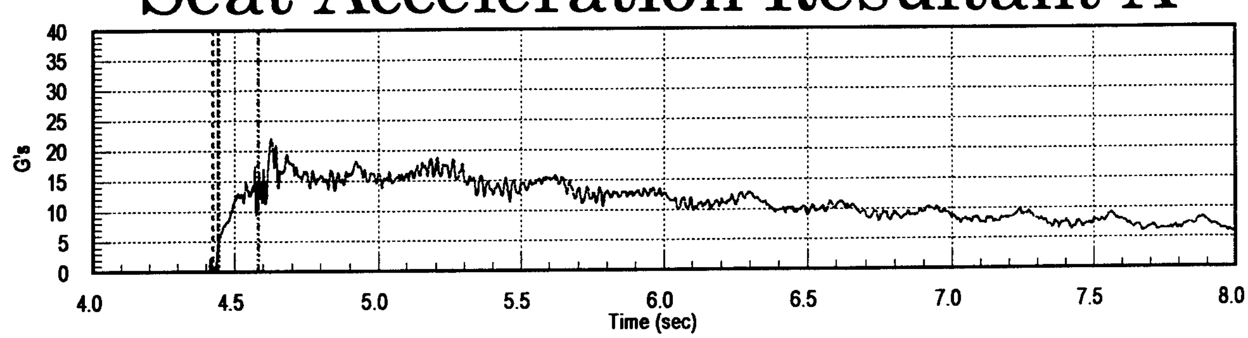
Seat Acceleration AY



Seat Acceleration AZ



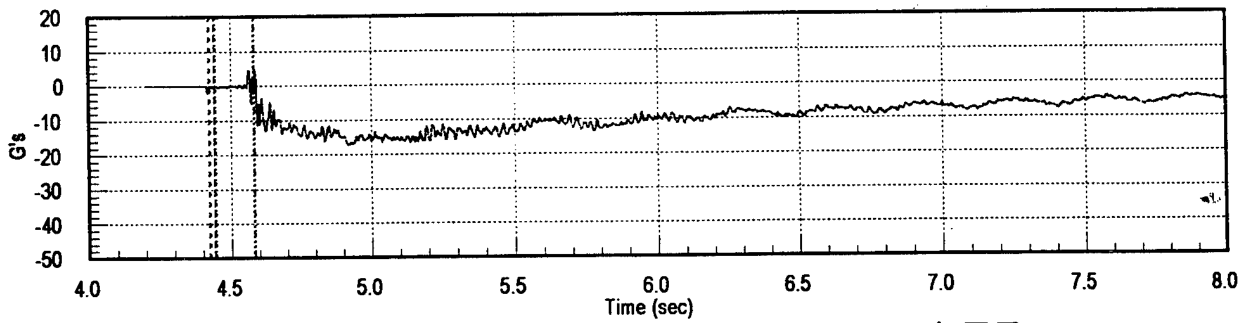
Seat Acceleration Resultant A



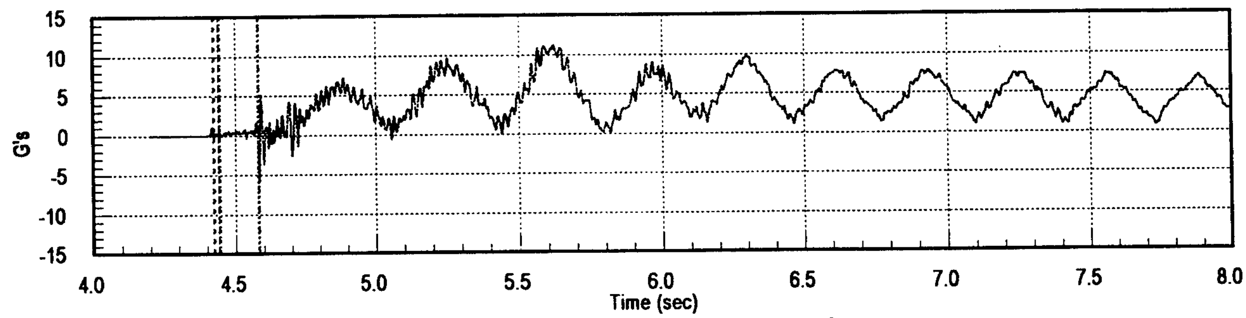
B-1

FL097516, 480 KEAS, 56,000 Ft

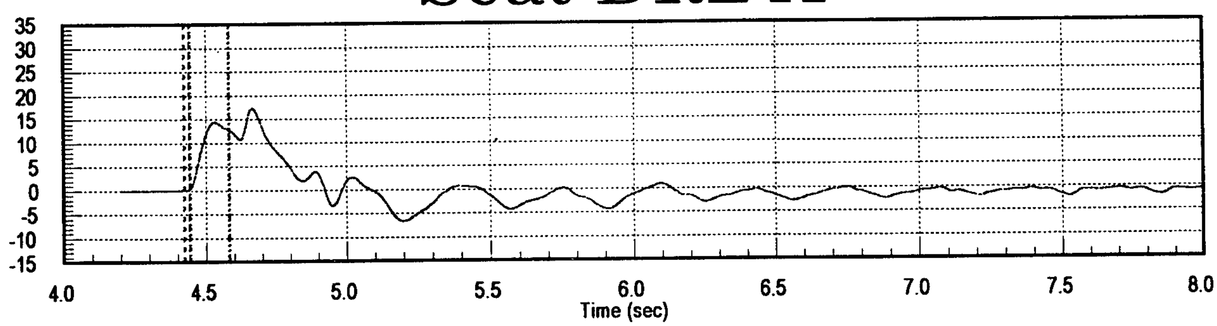
Seat Acceleration AX



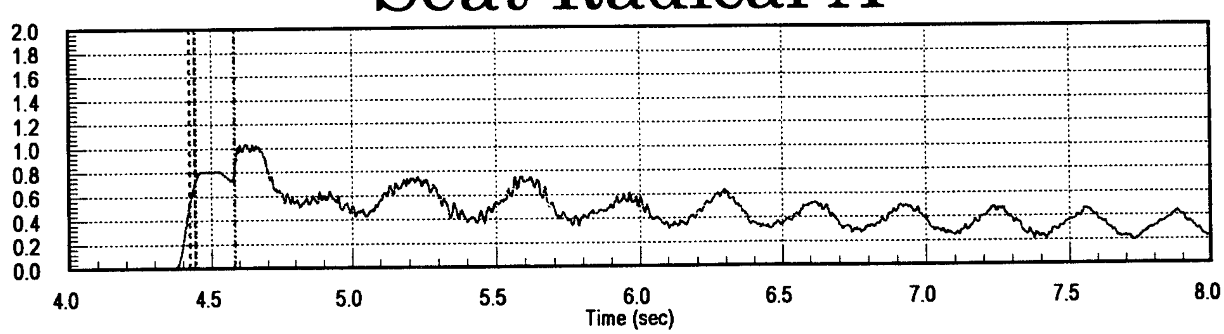
Seat Acceleration AY



Seat DRZ A



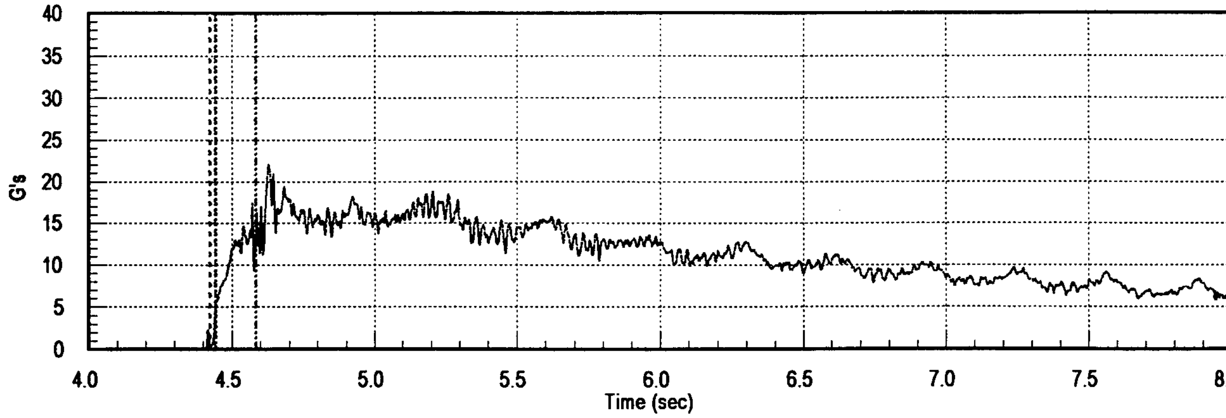
Seat Radical A



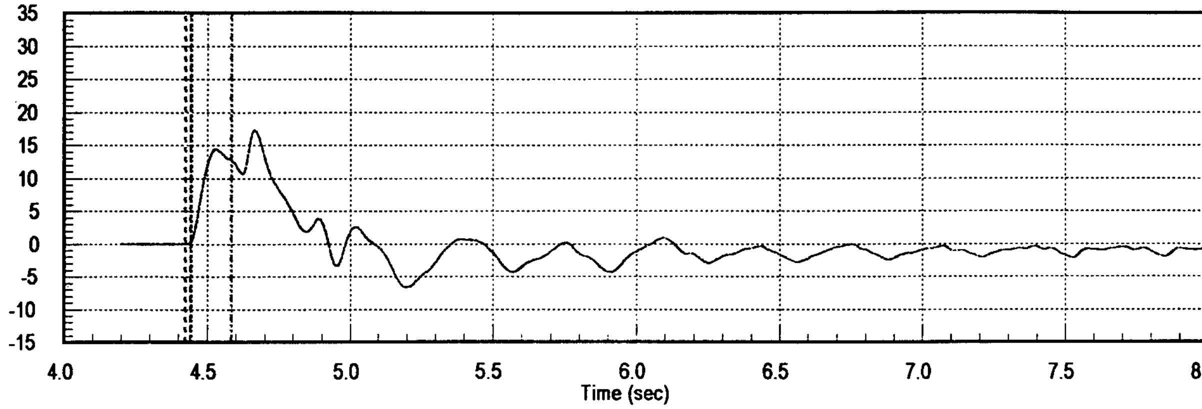
B-2

FL097516, 480 KEAS, 56,000 Ft

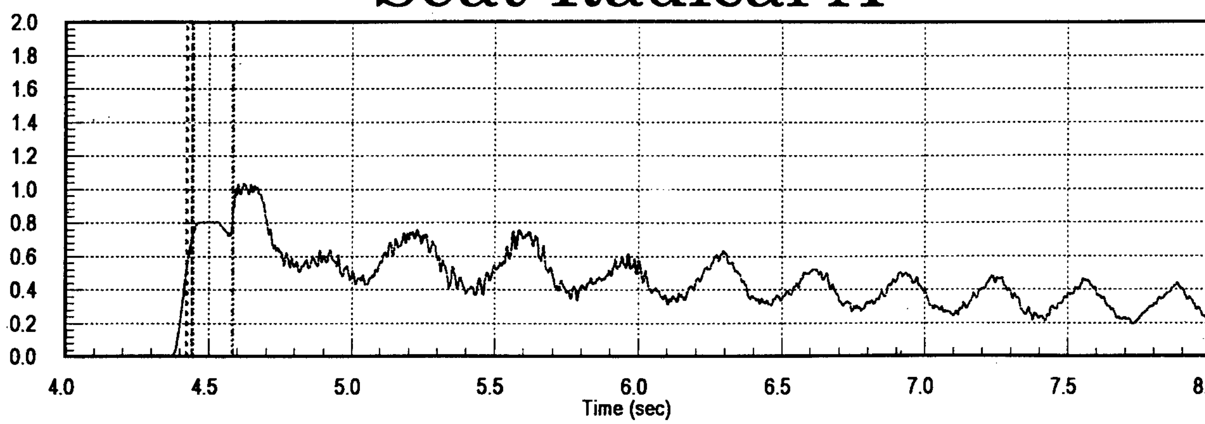
Seat Resultant A



Seat DRZ A



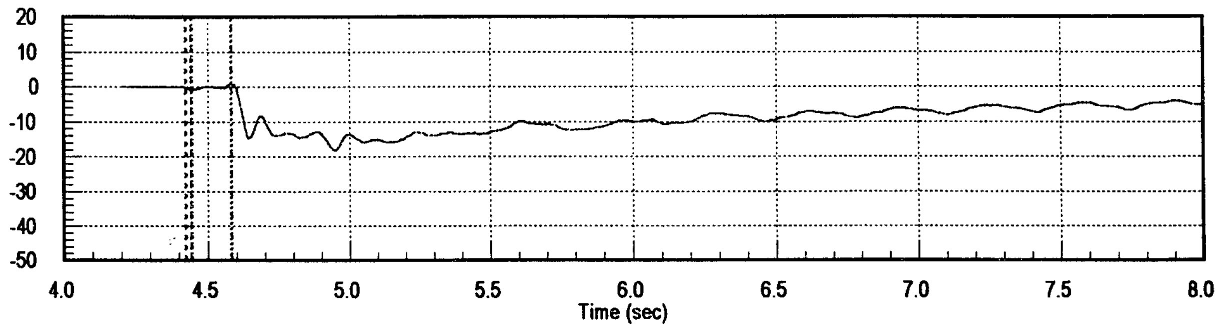
Seat Radical A



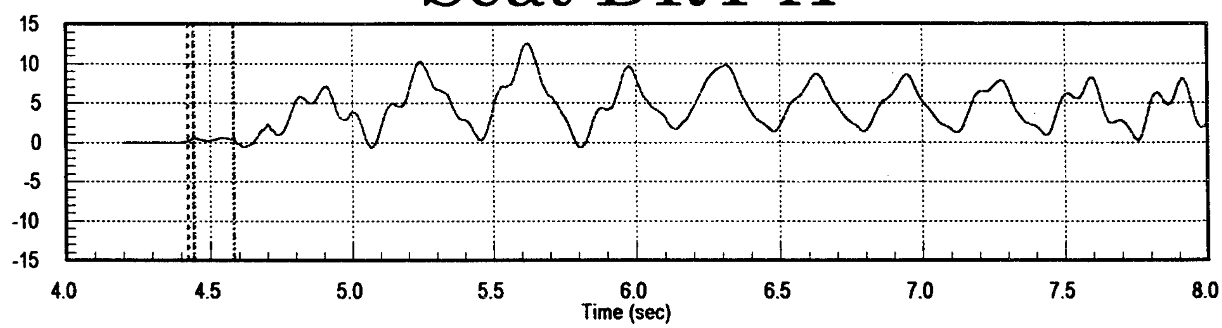
B-3

FL097516, 480 KEAS, 56,000 Ft

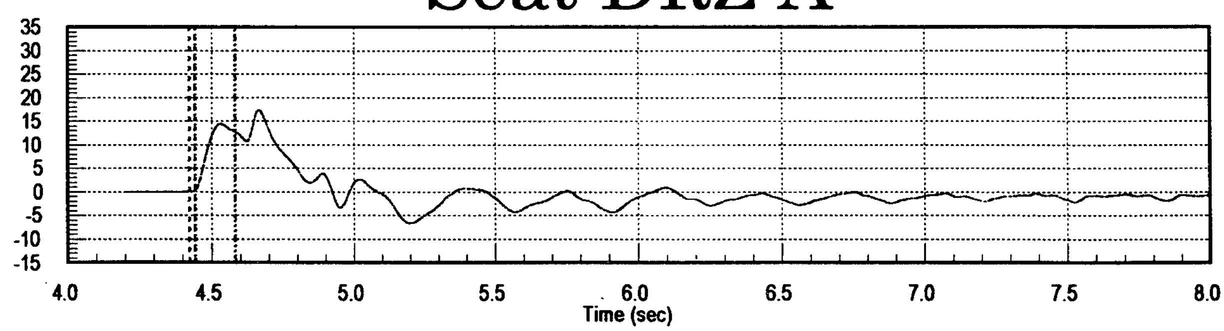
Seat DRX A



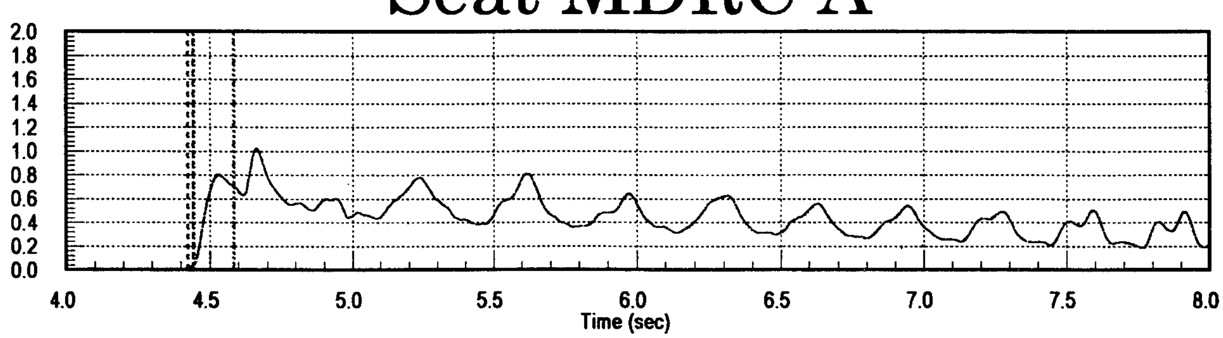
Seat DRY A



Seat DRZ A



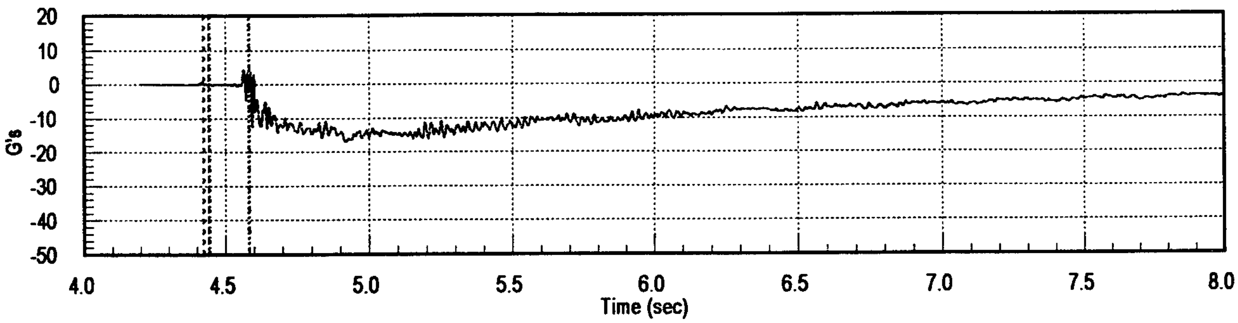
Seat MDRC A



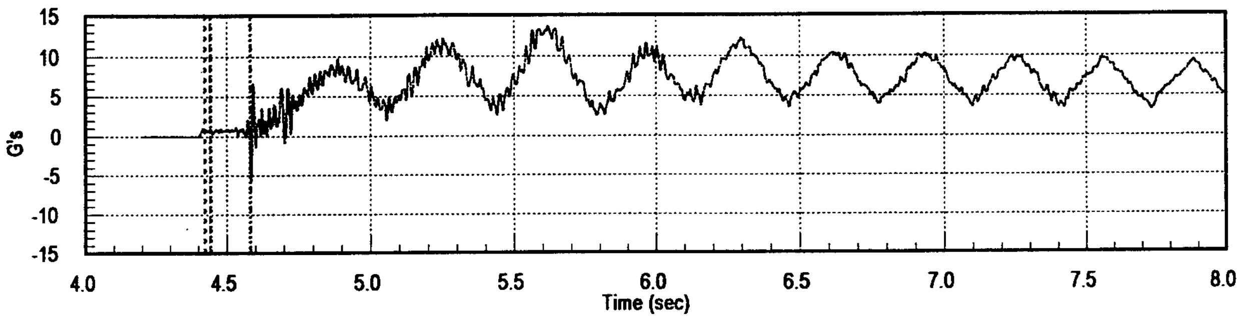
B-4

FL097516, 480 KEAS, 56,000 Ft

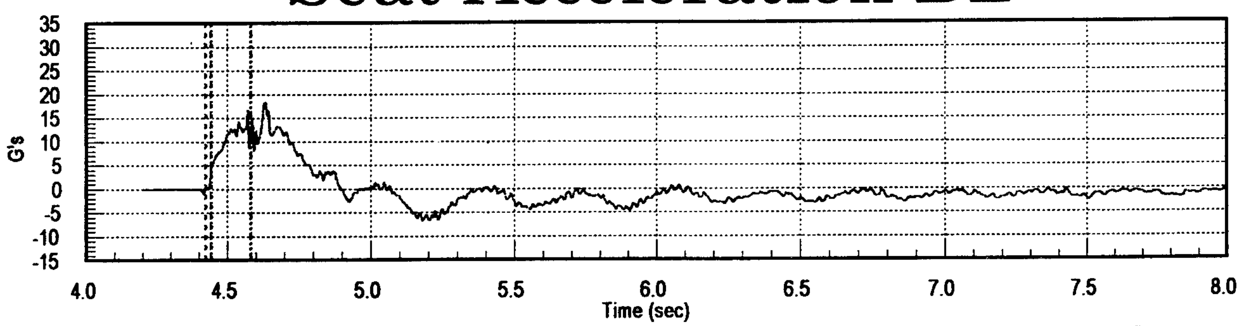
Seat Acceleration BX



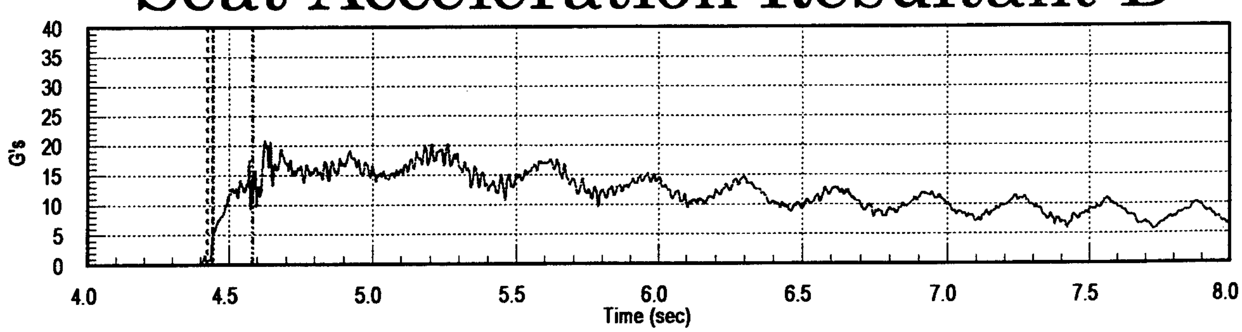
Seat Acceleration BY



Seat Acceleration BZ



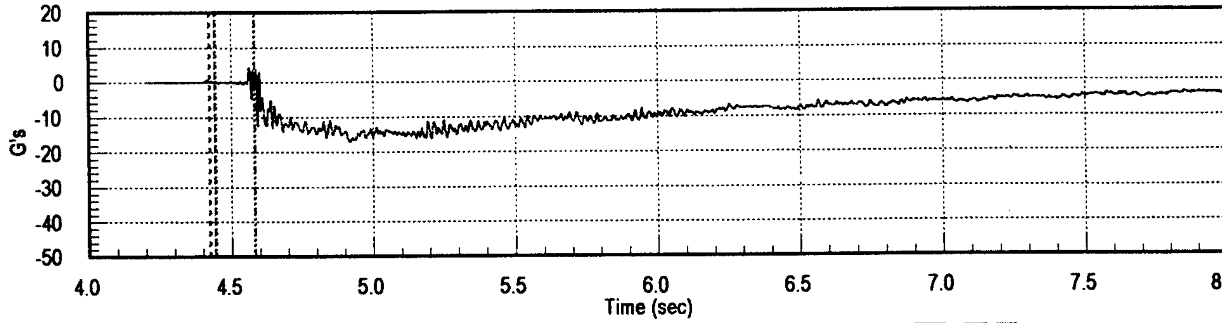
Seat Acceleration Resultant B



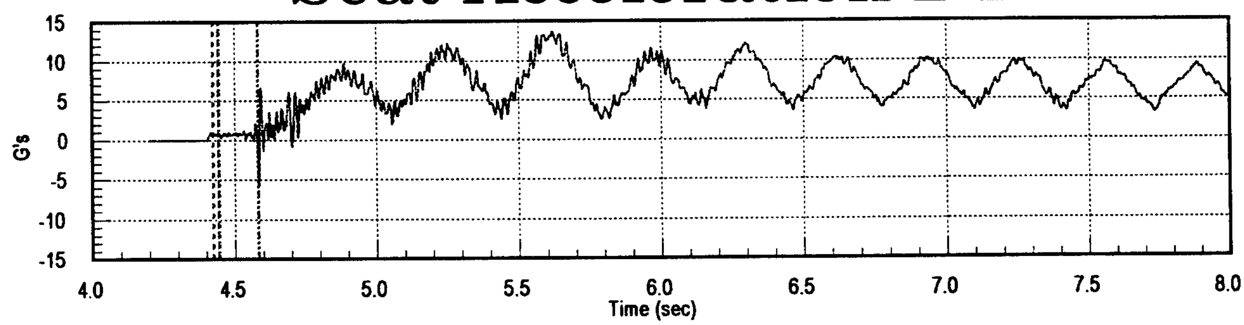
B-5

FL097516, 480 KEAS, 56,000 Ft

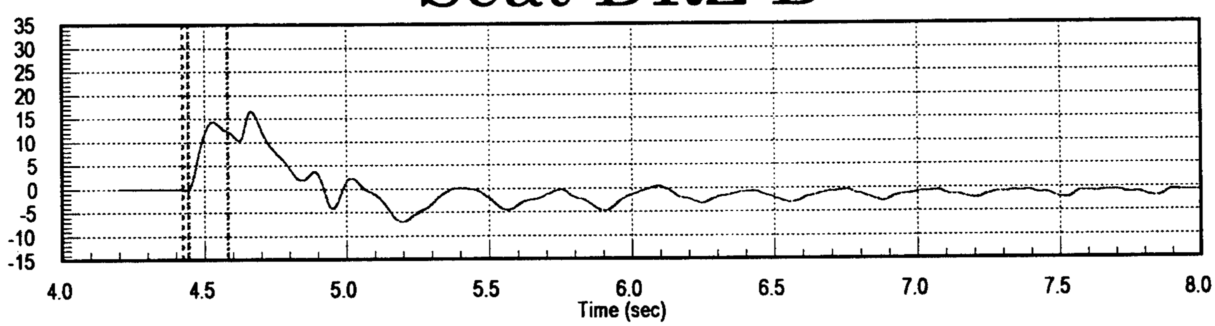
Seat Acceleration BX



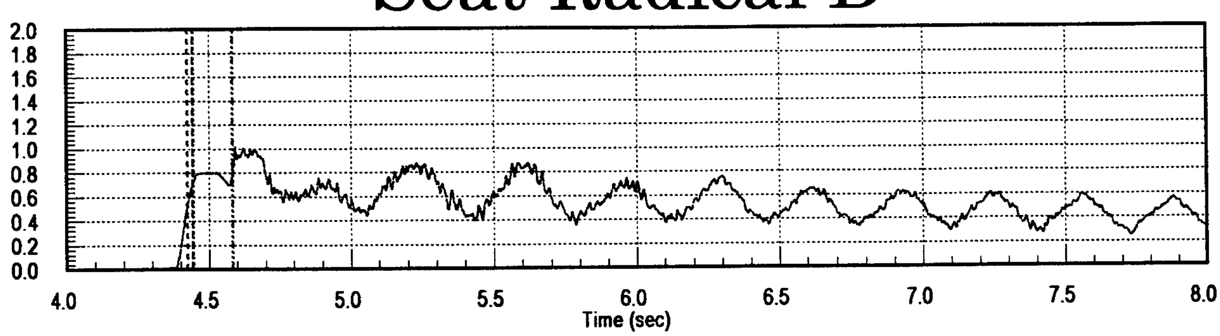
Seat Acceleration BY



Seat DRZ B

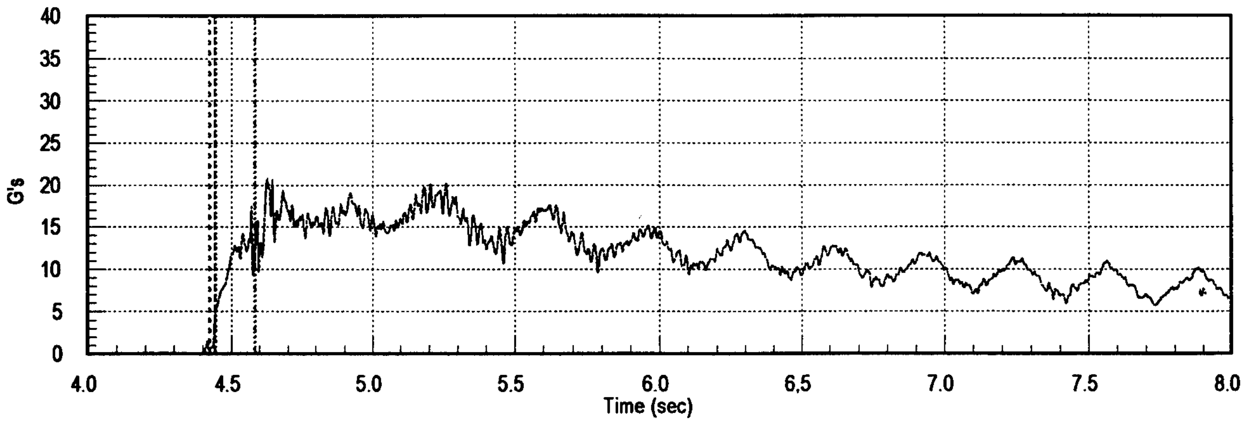


Seat Radical B

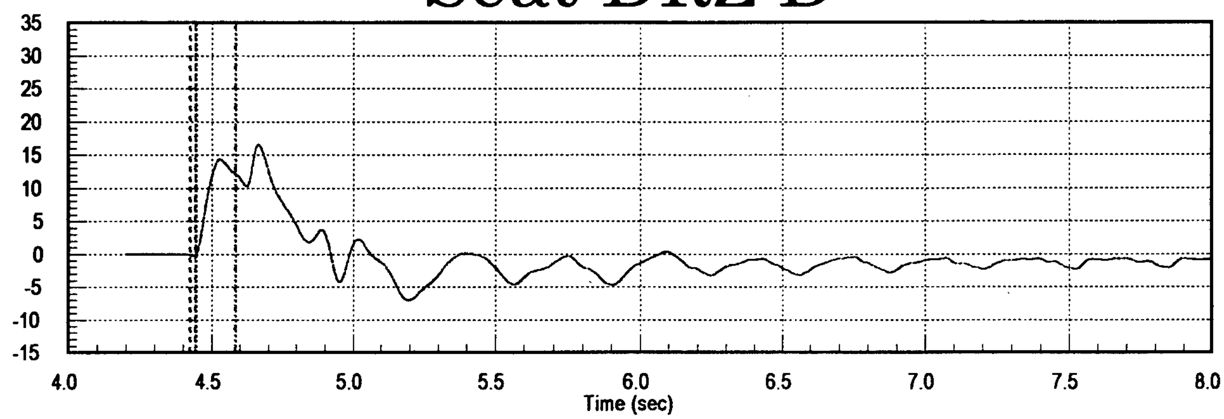


FL097516, 480 KEAS, 56,000 Ft

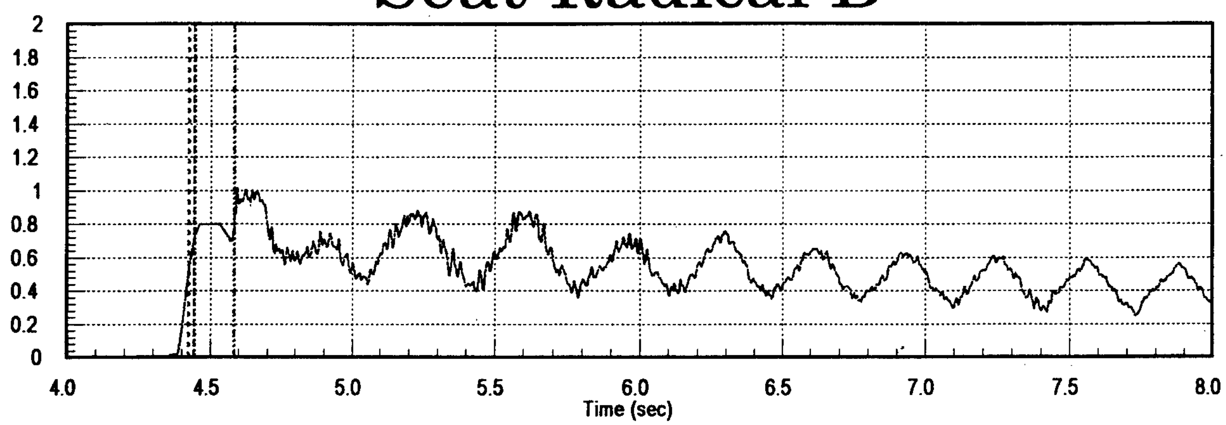
Seat Resultant B



Seat DRZ B



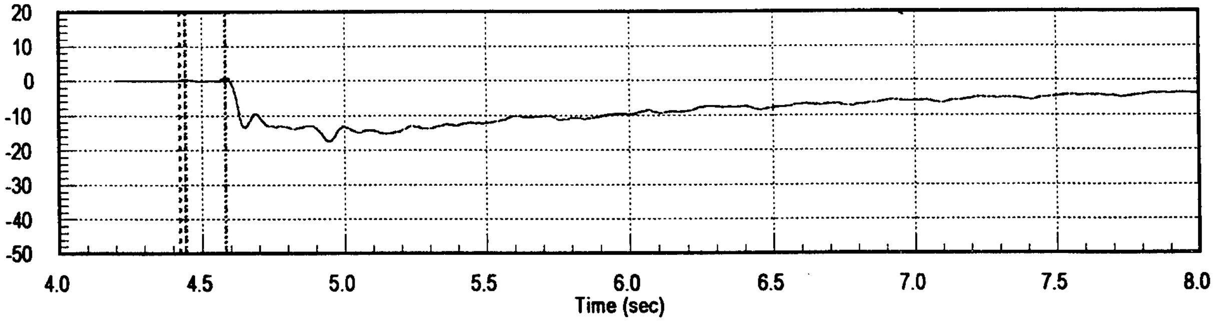
Seat Radical B



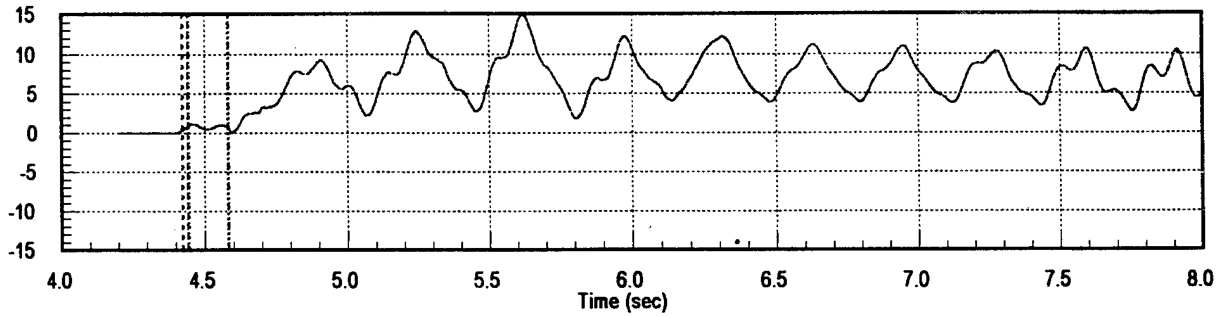
B-7

FL097516, 480 KEAS, 56,000 Ft

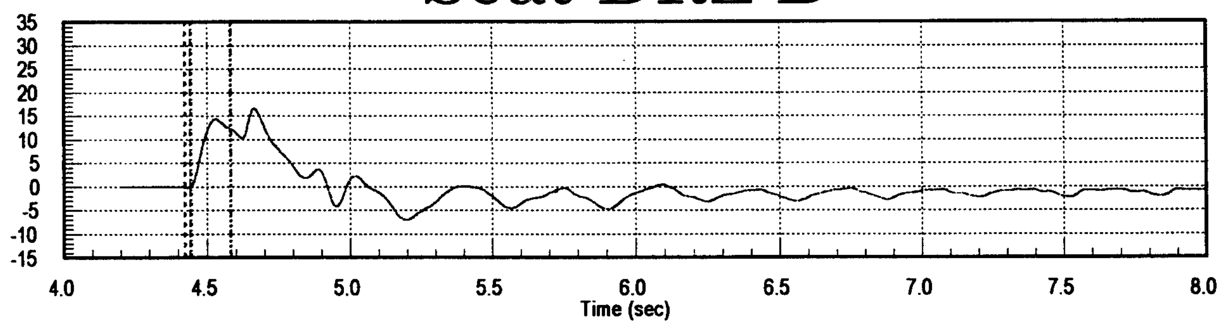
Seat DRX B



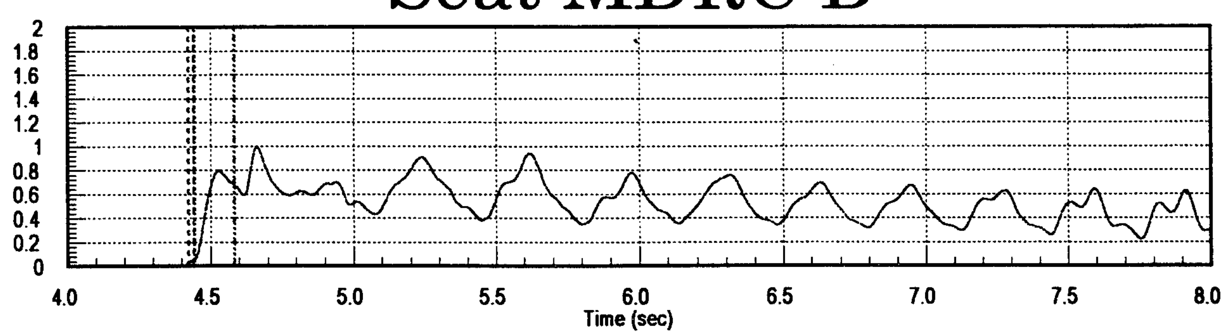
Seat DRY B



Seat DRZ B

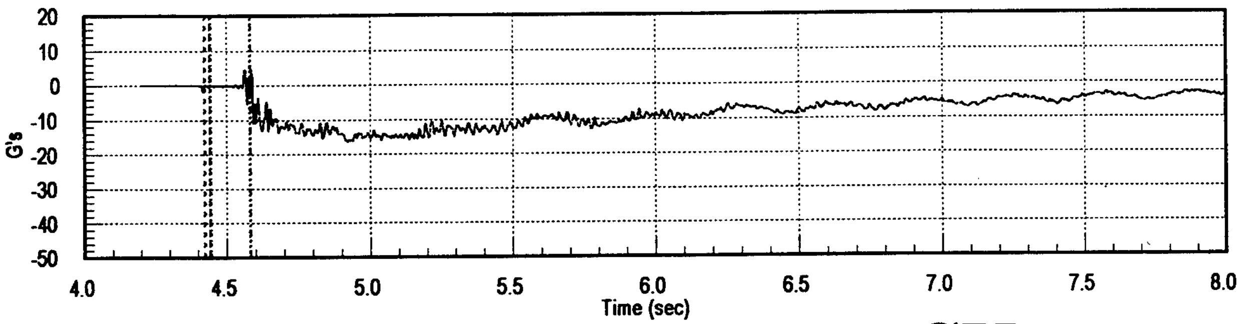


Seat MDRC B

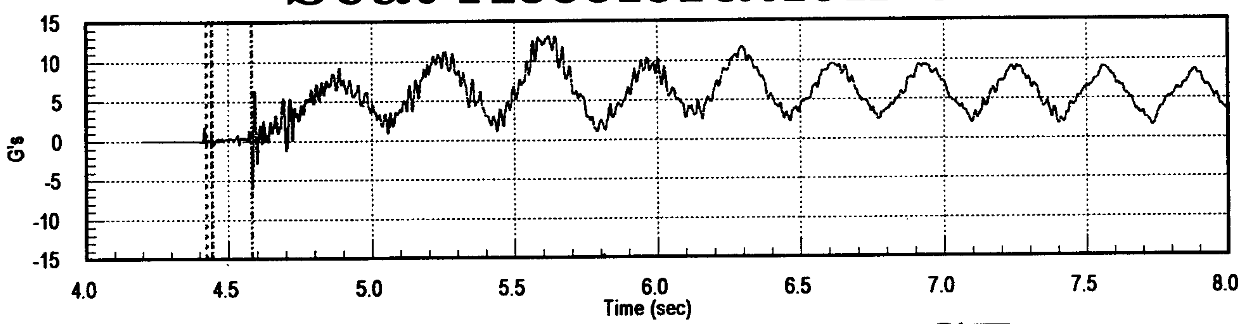


FL097516, 480 KEAS, 56,000 Ft

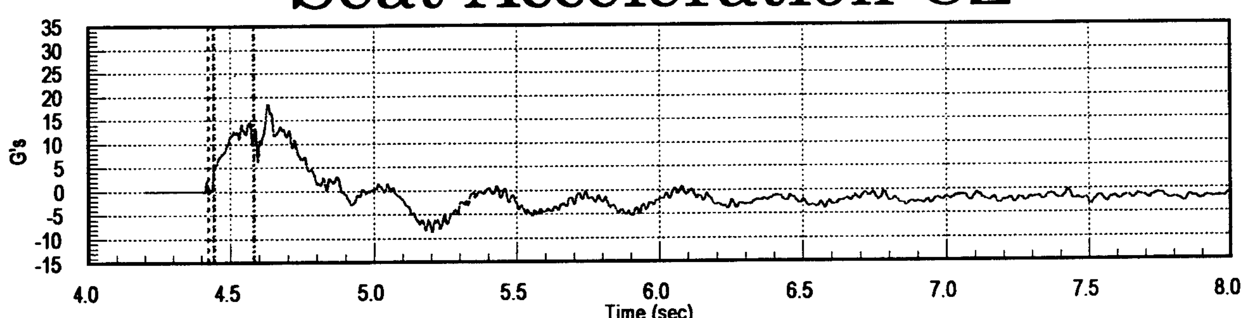
Seat Acceleration CX



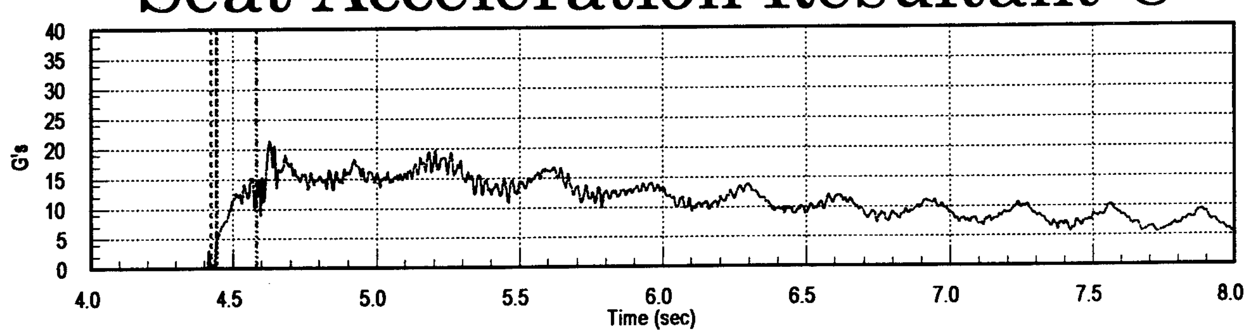
Seat Acceleration CY



Seat Acceleration CZ

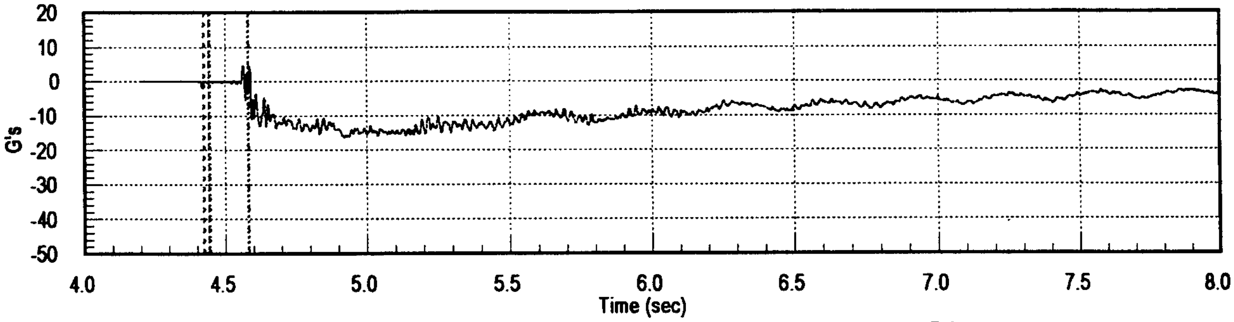


Seat Acceleration Resultant C

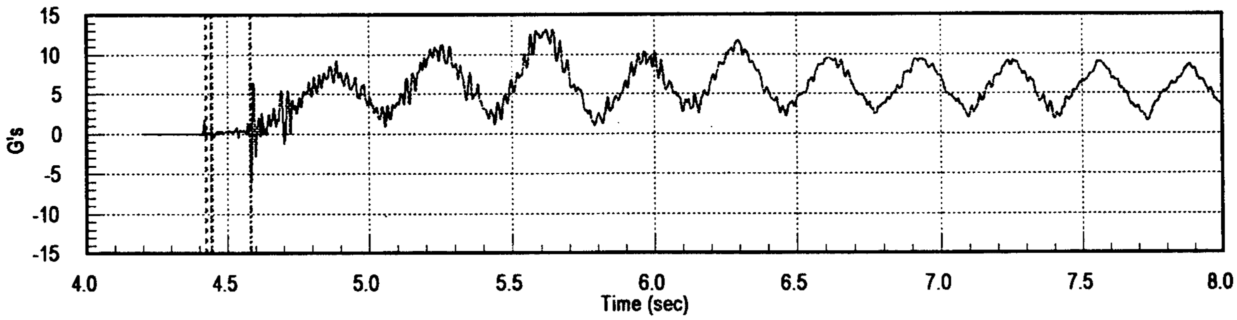


FL097516, 480 KEAS, 56,000 Ft

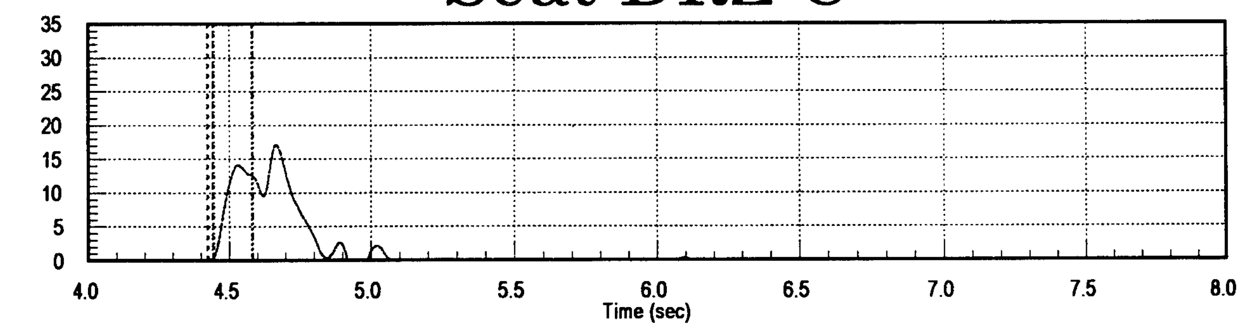
Seat Acceleration CX



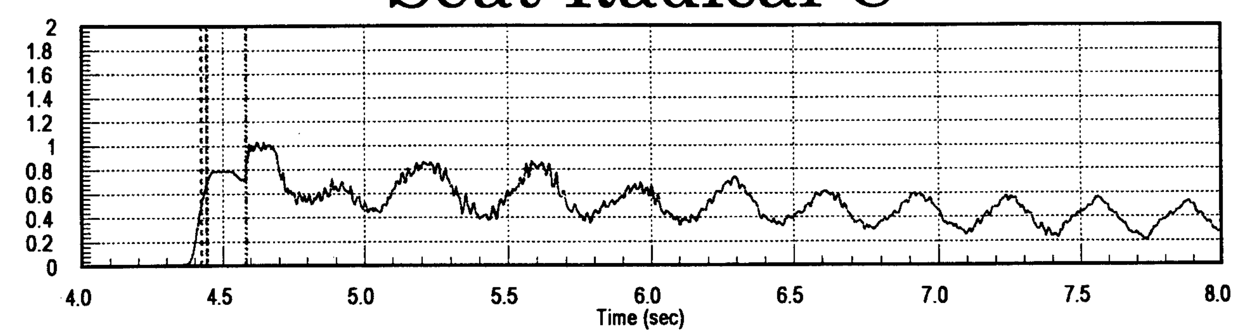
Seat Acceleration CY



Seat DRZ C

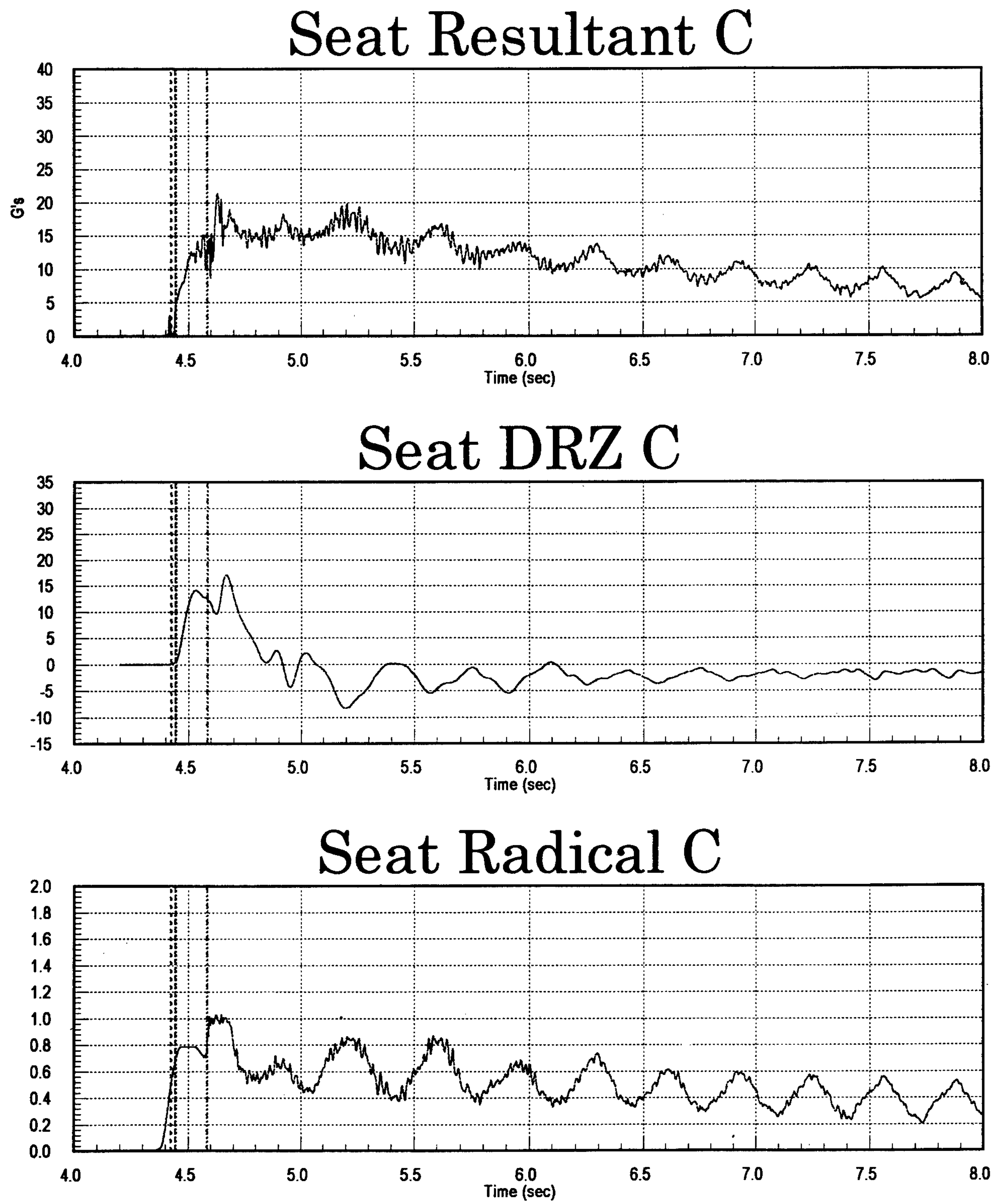


Seat Radical C



B-10

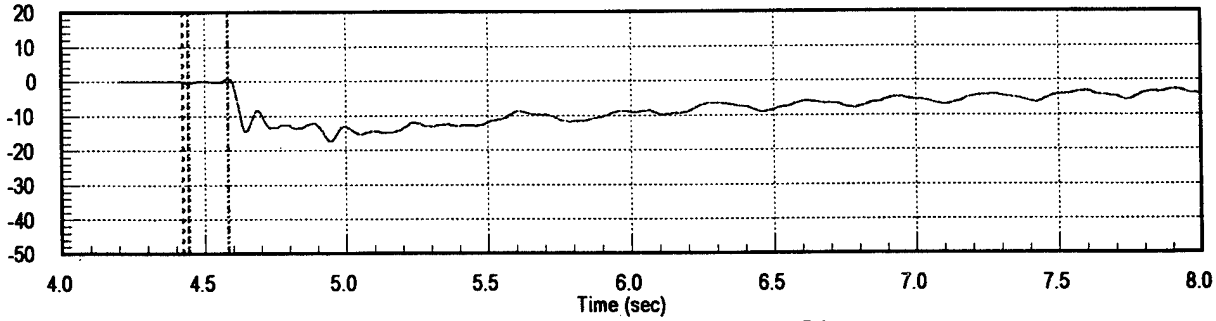
FL097516, 480 KEAS, 56,000 Ft



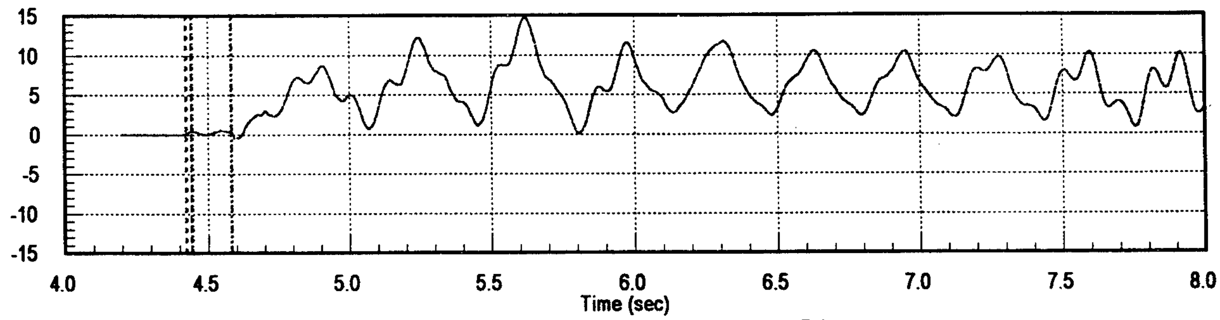
B-11

FL097516, 480 KEAS, 56,000 Ft

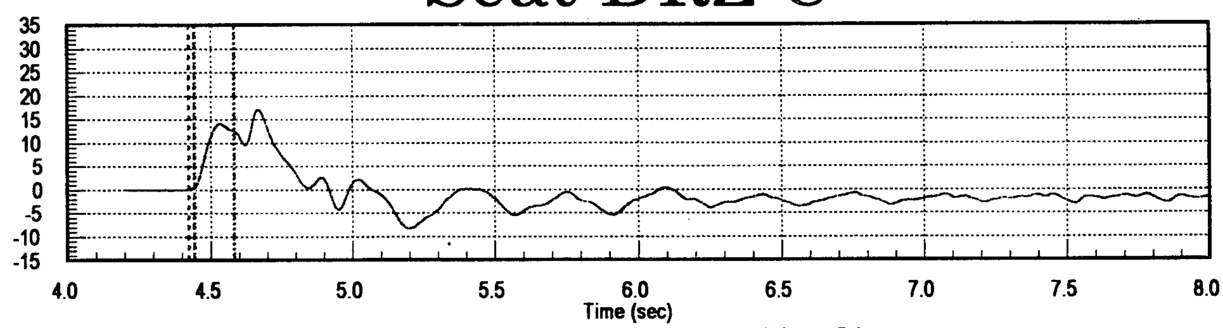
Seat DRX C



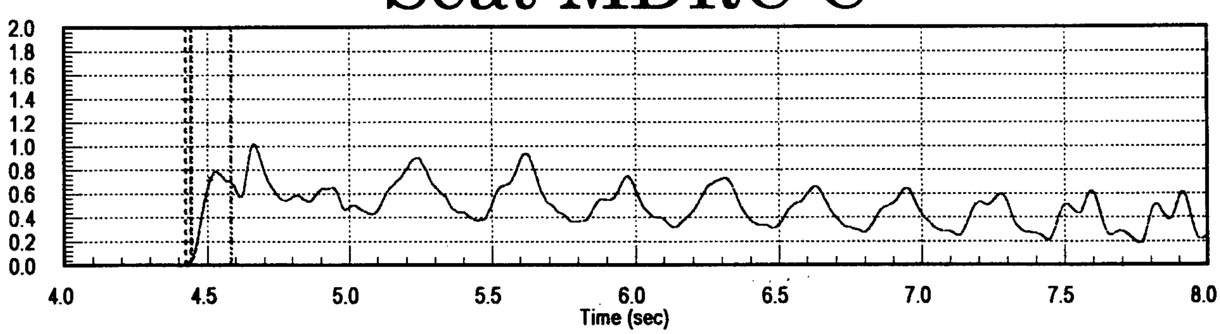
Seat DRY C



Seat DRZ C

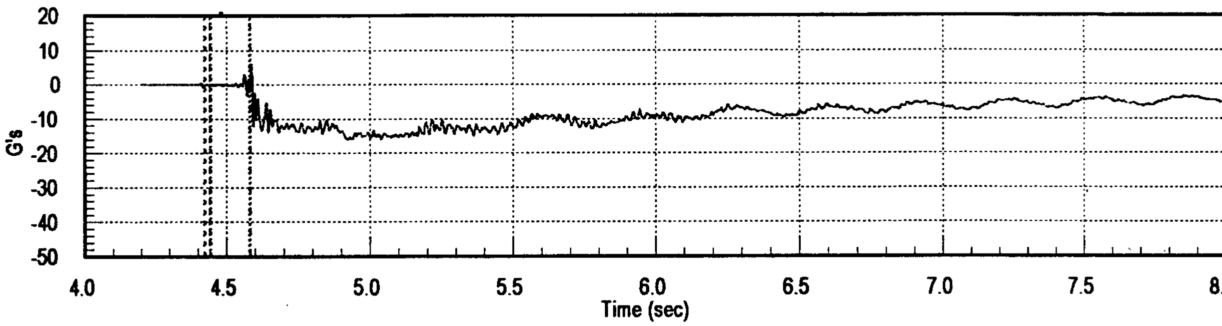


Seat MDRC C

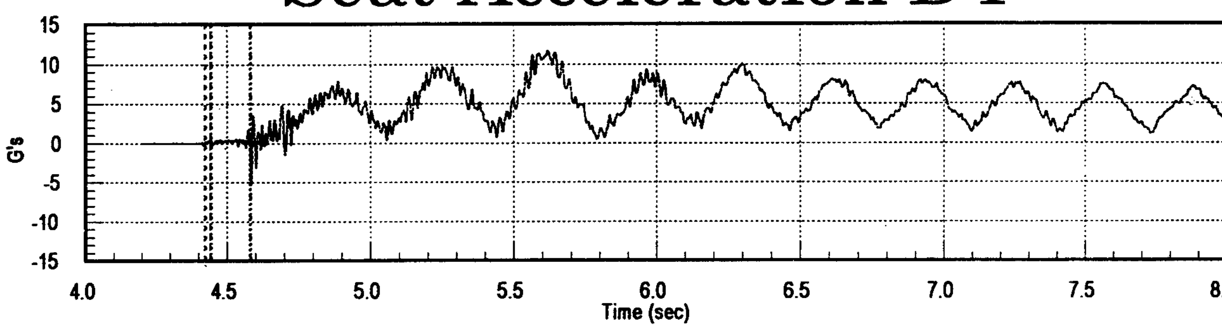


FL097516, 480 KEAS, 56,000 Ft

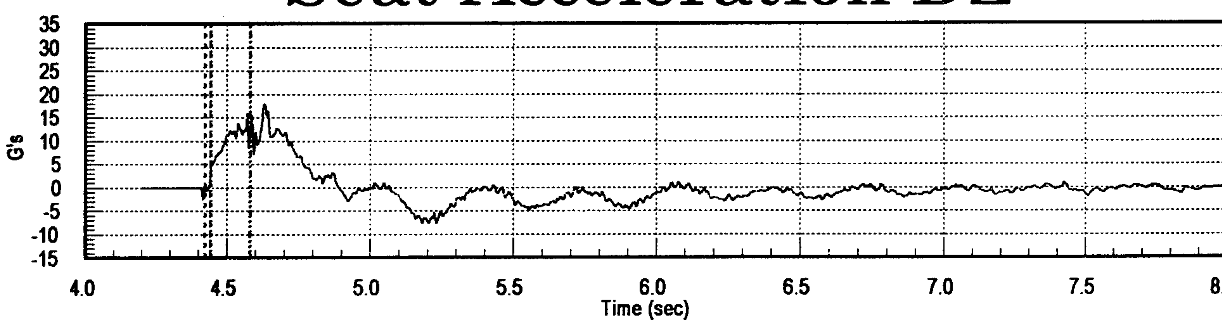
Seat Acceleration DX



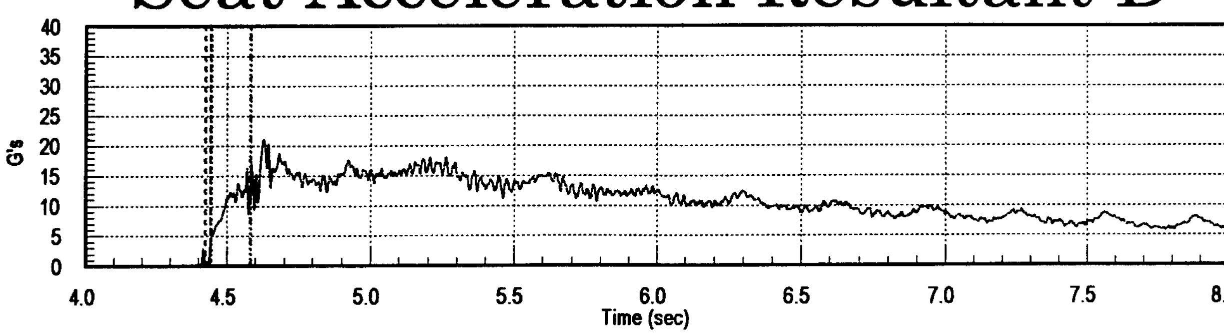
Seat Acceleration DY



Seat Acceleration DZ



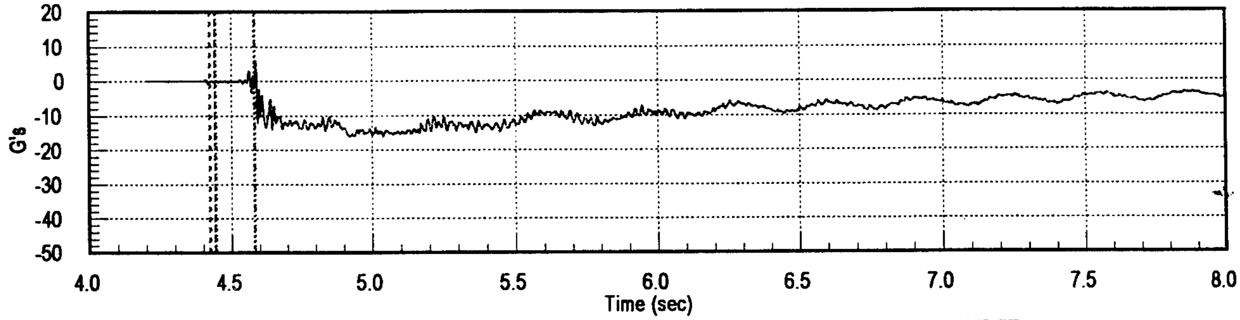
Seat Acceleration Resultant D



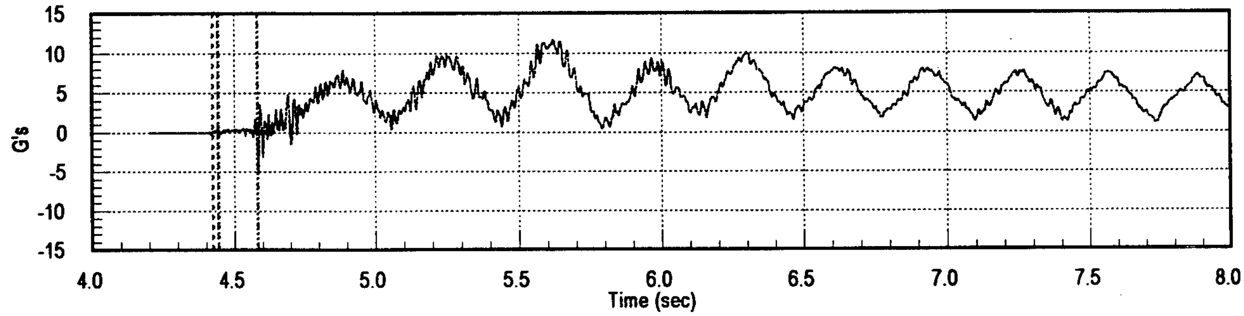
B-13

FL097516, 480 KEAS, 56,000 Ft

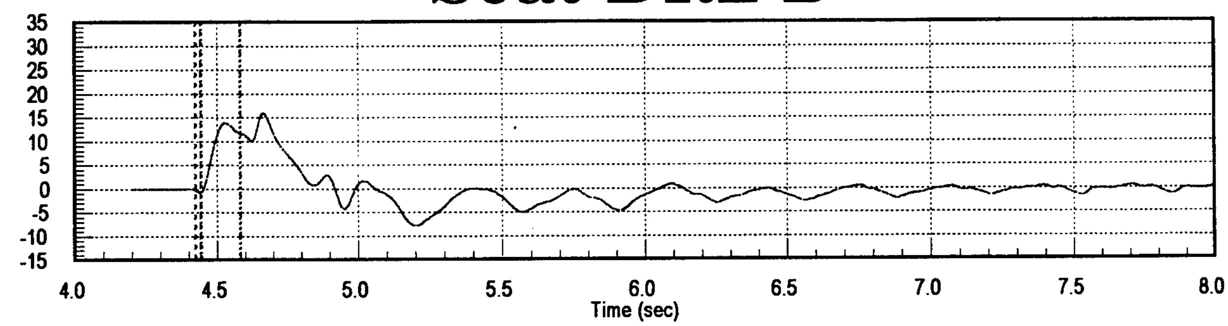
Seat Acceleration DX



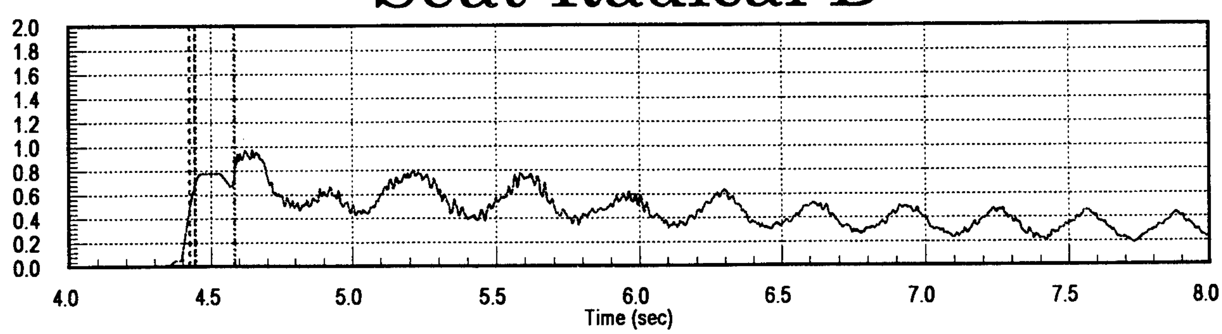
Seat Acceleration DY



Seat DRZ D

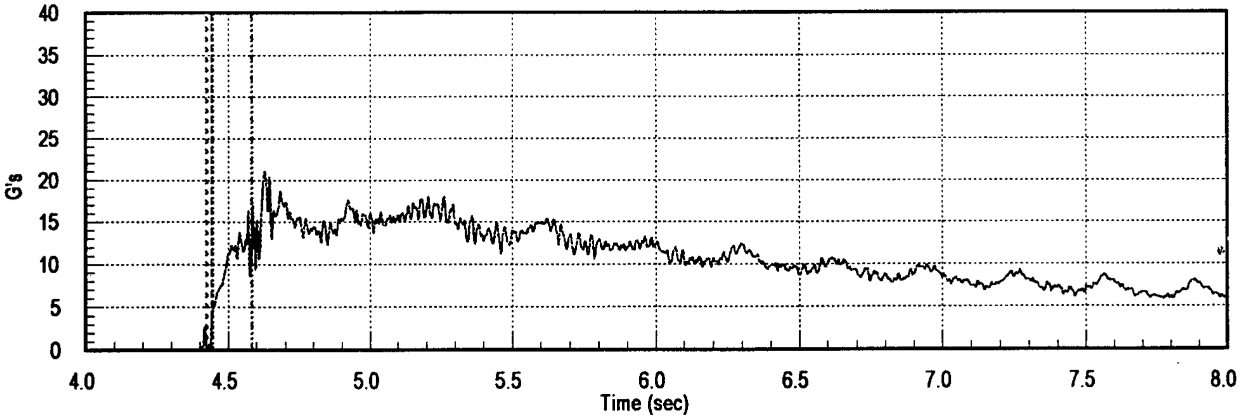


Seat Radical D

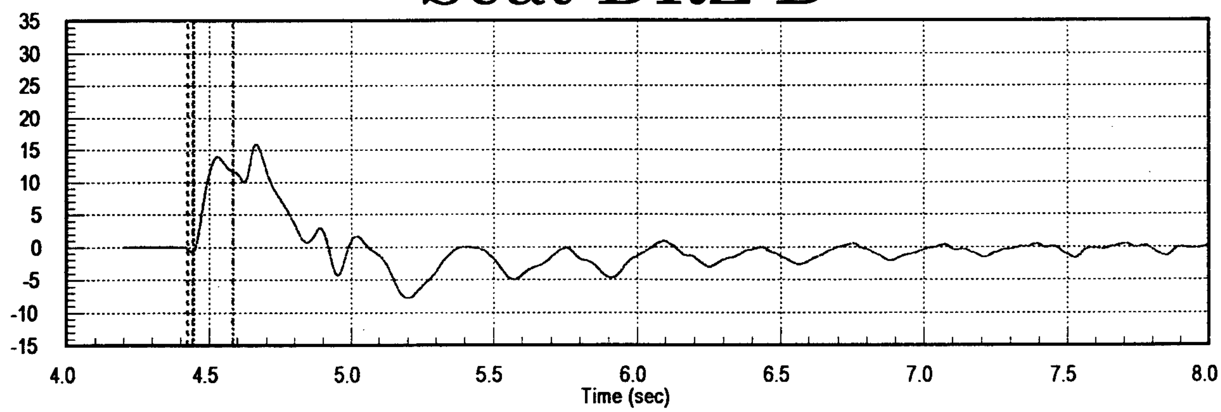


FL097516, 480 KEAS, 56,000 Ft

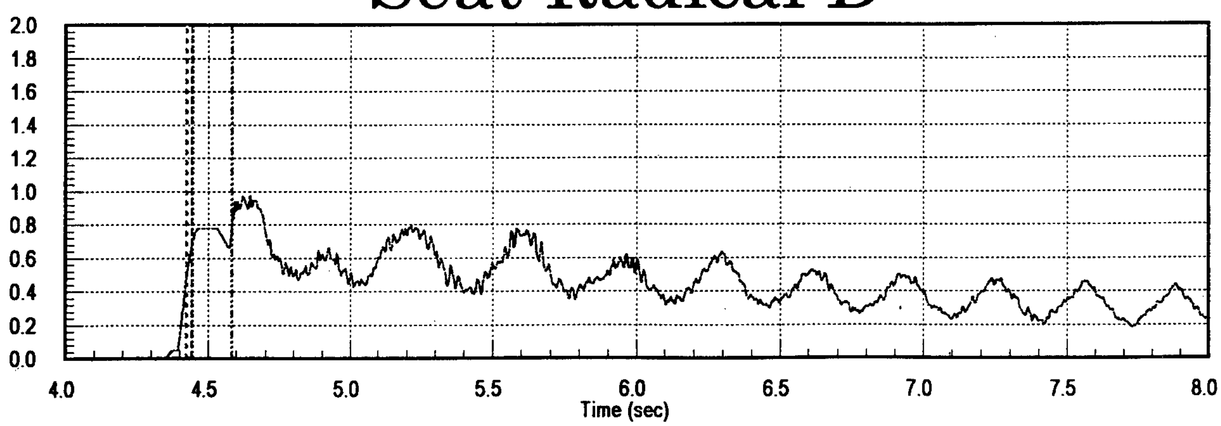
Seat Resultant D



Seat DRZ D



Seat Radical D



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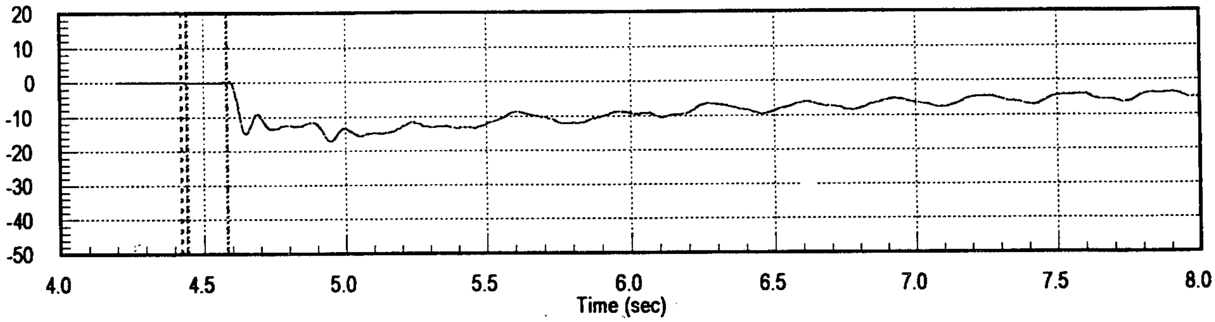
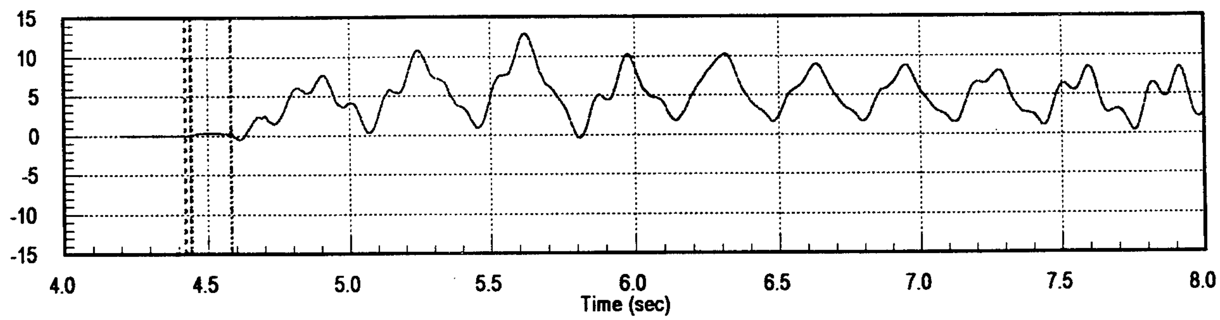
FL097516, 480 KEAS, 56,000 Ft

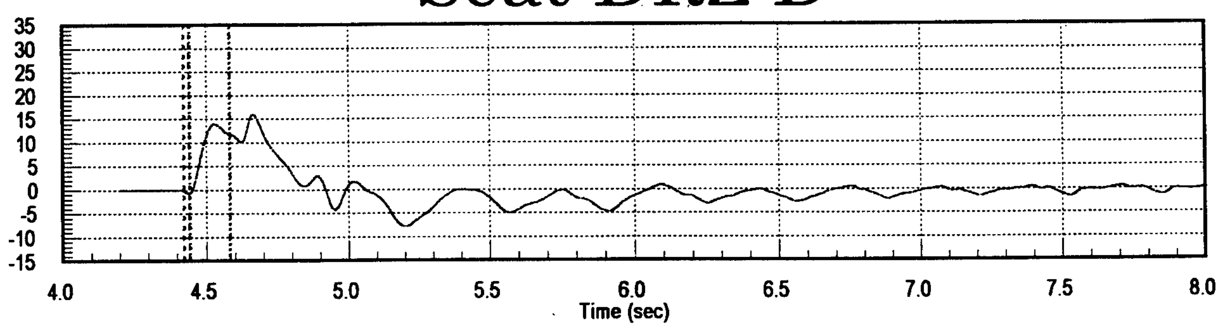
Seat DRX D



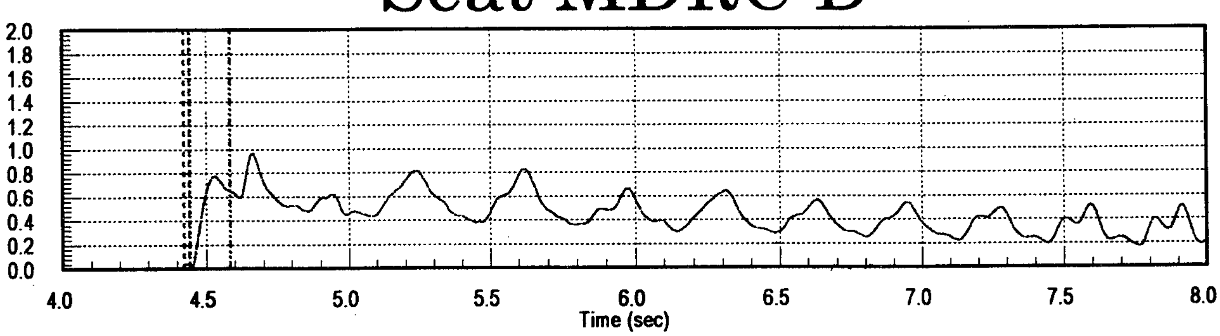
Seat DRY D



Seat DRZ D



Seat MDRC D



B-16

Appendix J

Compact Disc Data

The digital data in ASCII format shown in Appendices G, H, and I have been included on a supplemental CD-ROM disk available as an attachment to this report. Also included on the disk are MS Word 6.0 files of this report, PowerPoint files of the presentation of this material at the 1994 SAFE Symposium, digital data from the qualification tests, various digital bitmap images of the test program, and several avi digital video clips.

At the time of printing, additional tests of the K-36D had been performed at Holloman AFB using the Multi-Axis Seat Ejection (MASE) sled at low speeds and adverse attitudes. Data analysis is currently being conducted. However, data from these tests are also included on the CD-ROM.

The contents of the CD-ROM is as follows:

testcond.txt	Basic test conditions for each ejection test.
testcond.doc	Word 6.0 file with basic test condition table.
channels.txt	Descriptions of the data channels.
channels.doc	Word 6.0 file with descriptions of the data channels and of which tests those channels were measured.
wrd6view.exe	Word 6.0 viewing application
k-36tp.doc	Word 6.0 file of FCT Test Plan
k-36tp2.doc	Word 6.0 file of Low Speed/Adverse Attitude Test Plan
files.doc	Word 6.0 file of the files and directory structure of this disk
flies.txt	Text file of the files and directory structure of this disk
ADVERSE	Adverse Attitude tests at Holloman AFB
82E-XX	Ejection tests at Holloman AFB, MASE Sled, ADAM Manikin XX indicates the test designation
DYNRESP	Dynamic Response Calculations Data Files
LOWSPEED	Low Speed tests at Holloman AFB
82E-XX	Ejection tests at Holloman AFB, MASE Sled, ADAM Manikin XX indicates the test designation
DYNRESP	Dynamic Response Calculations Data Files
HIGHSPEED	
FLXXXXYY	Ejection tests in Russia from the Flying Laboratory XXXX is planned velocity in Km/hr YY is planned altitude in Km
SLXXXX	Russian Rocket Sled tests XXXX is planned velocity in Km/hr

SK	Indicates the test was conducted with Russian manikin (SKIF)
DYNRESP	Dynamic Response Calculations Data Files
QUALIFY	Qualification tests at Zvezda Design Bureau in Russia
WTXXXX	Russian wind tunnel tests XXXX is planned velocity in Km/hr
BVKX	Russian Catapult Tower (Big Vertical Catapult) X is the test number
SK	Indicates the test was conducted with Russian manikin (SKIF)
HELMET	Wind tunnel tests of US helmets on K-36 Ejection Seat
55PXXX	HGU-55/P Helmet XXX is the actual test velocity in KEAS
68PXXX	HGU-68/P Helmet XXX is the actual test velocity in KEAS

PROTOCOL Test/data reports for tests conducted at Holloman AFB

SAFE94	PowerPoint files of presentations at SAFE panel in 1994
A	Introduction/Overview
B	Implementation
C	Seat Operation
D	Manikins, Instrumentation, Data-Processing, Test Facilities
E	Certification Testing
F	Seat Performance
G	US Helmet Evaluation
H	Summary/Future Efforts
REPORT	Final report for the tests conducted in Russia in 1993 Contains Word for Windows 6.0 files
a_tblcnt.doc	Report cover page, indices, and structure
b_intro.doc	Report introduction
c_techap.doc	Technical approach
d_seat.doc	Test Item
e_mthds.doc	Methods, test equipment, and facilities
f_datapr.doc	Data processing
g_condct.doc	Conduct of tests
h1_rslts.doc	Test results
h2_rslts.doc	Test results, tables
i_disc.doc	Analysis and Discussion
j_summry.doc	Summary
k_ref.doc	References
l_appnd.doc	Appendices

PHOTO	Contains *.bmp digital bitmap scanned files of photos of the various tests
VIDEO	Contains *.avi video files of various tests. Can use Media Player (under Accessories) in MS Windows to view these.
PHOTO	Contains *.bmp digital bitmap

To obtain a copy of the CD-ROM, submit requests to:

ROCKWELL INTERNATIONAL
NORTH AMERICAN AIRCRAFT DIVISION
P.O. Box 3644
Seal Beach, CA 90740
Attn.: Rob Zegler

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